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Central stars of planetary nebulae ⋆,⋆⋆

II. New OB-type and emission-line stars

W. A. Weidmann[1,⋆⋆⋆] and R. Gamen[2,⋆⋆⋆⋆]

[1] Observatorio Astronómico Córdoba, Universidad Nacional de Córdoba, Argentina
e-mail: walter@mail.oac.uncor.edu
[2] Instituto de Astrofísica de La Plata, CCT La Plata-CONICET, Universidad Nacional de La Plata, Argentina
e-mail: rgamen@fcaglp.unlp.edu.ar

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ABSTRACT

Context. There are more than 3000 confirmed and probably known Galactic planetary nebulae (PNe), but central star spectroscopic information is available for only 13% of them.
Aims. We have undertaken a spectroscopic survey of the central stars in PNe to identify their spectral types.
Methods. We performed spectroscopic observations at low resolution with the 2-m telescope at CASLEO, Argentina.
Results. We present the spectra of 46 central stars of PNe, most of them are OB-type and emission-line stars.

Key words. surveys – planetary nebulae: general – Atlases – stars: Wolf-Rayet

1. Introduction

Planetary nebulae (PNe) are some of the most beautiful objects in the sky. There are about 3000 catalogued PNe in our galaxy, but only 13% of their progenitors have been spectroscopically identified. The variety of spectral types in these stars was shown by Weidmann & Gamen (2011, hereafter Paper I).

Identifying of the ionizing star of a PN is not always easy because most of them are optically faint objects (low luminosity), and sometimes they are not at the geometric center, because the nebula interacts with the interstellar medium (Tweedy & Napiwotzki 1994). Also, PNe are concentrated toward the plane and bulge of the Galaxy, where crowding and interstellar dust make it difficult to observe and identify they progenitors. That the PNe are easily confused with other types of objects (Frew & Parker 2010) complicates this picture even more and introduces confusion into statistical works. At present, many non-PNe remain hidden in the catalogs of PNe (Paron & Weidmann 2010).

A strong effort has been made in recent years to improve and increase the spectroscopic observations of central stars of PN (CSPN), which together with stellar atmosphere models should help for understanding the physics of this heterogeneous group of stars. However, the faintness of most of the CSPNe makes their spectroscopic observation a very time-demanding task, and thus the studies of these objects progress slowly. A consequence of all these problems is the very low number of new identified OB-type CSPNe (harder to detect than emission-line stars). There were 60 OB stars listed in Acker et al. (1992), and only seven newly identified OB stars have been reported until 2010 (see Paper I).

We are carrying out a spectroscopic survey of unclassified CSPN (see Paper I), the first results of which are presented in this second paper. We describe the observations and reduction of data in detail (Sect. 2). We analyze and show the spectra of OB-type and emission-line stars for classification purposes and comparison studies (Sect. 3.1). We hope that this work will help guide future observations and lead to a more reliable determination of the stellar parameters of the objects presented here, in particular the absorption-line central stars.

2. Observations and data reduction

The REOSC spectrograph attached to the 2.15-m telescope at CASLEO, Argentina, was employed in this survey. It is equipped with a CCD Tek 1024 × 1024 pixels (24 μm) and a read-noise of 7.4 e^{-1} $pixel^{-1}$. A 300 line mm^{-1} grating, named #270 and blazed in the blue, was used, and it yielded a dispersion of 3.4 Å $pixel^{-1}$ to the first order (a resolving power $R \approx 2000$). On some nights, a grating of 600 line mm^{-1} (#260) was used (1.6 Å $pixel^{-1}$). The gratings were used with an unique tilt, giving a typical wavelength range of 3500–7000 Å (3875–5530 Å with the #260). The slit was always centered on the CSPN, oriented in the east-west direction and opened to 3″ (consistent with the seeing at the site). The wavelength calibration was performed using Cu-Ne-Ar comparison arcs. At least two spectrophotometric standards (from Hamuy et al. 1992) were observed during each observing night, and were used for flux calibration (these stars are detailed in Table 3). The 2D optical

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⋆⋆ The reduced spectra (FITS files) are available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsarc.u-strasbg.fr/viz-bin/qcat?J/A+A/531/A172

⋆⋆⋆ Fellow of Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

⋆⋆⋆⋆ Member of Carrera del Investigador CONICET, Argentina.

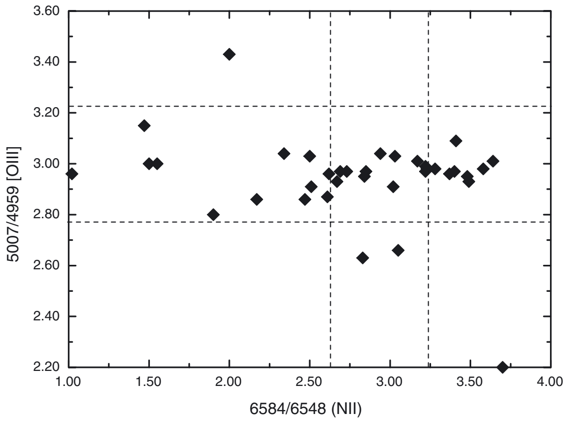

Fig. 1. The intensity ratios of the O III 4959, 5007 Å and the N II 6548, 6584 Å lines. The defined region indicates the value expected from the observational data compiled by Acker et al. (1989).

spectra were processed using IRAF[1], following standard techniques. In most of our spectra we did not subtract the nebular emission lines. For that reason some lines were useless for classification purposes. The spectra were flux-calibrated with the standard stars shown in Table 3 and the extinction coefficients calculated for CASLEO by Minniti et al. (1989), and dereddened using the $c(\mathrm{H}\beta)$ published by Tylenda et al. (1992).

The quality of the data and their reduction can be assessed by looking at the line ratios of [O III] 5007/4959 Å and [N II] 6584/6548 doublets, which are not very sensitive to nebular conditions. Figure 1 shows that the [OIII] line ratios lie around the expected value of 3.01 (Acker et al. 1989). The situation is quite different for the [NII] lines, but this is due to the blending of these lines with Hα in our spectra.

3. Spectral classification

3.1. Brief description of spectral types observed in CSPN

CSPN can be divided into two well-defined groups, i.e. H-rich and H-poor (Méndez 1991). For stars in the former group, hydrogen is the dominant element. Their more common spectral types are O and O f and, to a lesser extent, early B (stars with $T_{\mathrm{eff}} < 20\,000$ K could not ionize the nebula), B[e], sdO, and white dwarfs of the types DA and DAO[2].

In the H-poor group, the stellar spectrum is almost free of hydrogen, while helium and carbon are the most prominent elements. In general the spectra of H-poor CSPN is dominated by the broad and intense emission lines typical of Wolf-Rayet stars [WR], usually of [WC] subtype, and a few of [WO]. The [WC] stars are dominated by the C III 5696 Å line, since the C IV lines are fainter, and their disappear after the [WC9] class (see Méndez 1982 and 1991). The [WO] stars are dominated by the C IV 5806 Å lines (and high excitation O-lines, e.g. O VI 3822 Å). In addition, there are a couple of debatable galactic [WN] CSPN (PMR 5 discovered by Morgan et al. (2003) but questioned by Todt et al. (2010a), PB 8, classified by Todt et al. (2010b) as [WN/WC] and A 48 classified by DePew et al. (2011) as a possible [WN] or [WN/WC]) but with a rather high H abundance of 40%, which might mean that a spectral type Of-WR(H) is a preferable description of the spectrum.

A subgroup of CSPN, defined by Tylenda et al. (1993, hereafter TA1993), shows emission lines narrower and weaker than the [WR] stars, called wels (weak emission-line stars). Differences between wels and [WC] are subtle, and there is no clear criterion to distinguish both spectral types (see e.g. Marcolino & de Araújo 2003). The most important feature in wels is the C IV 5806 Å that is systematically weaker and narrower than for the [WC4-8]. Moreover, C III is very weak or else absent in canonical wels. The blend of C and N ions at 4650 Å is also generally detectable in wels (note the emission of C IV at 4658 Å in Fig. 10). Corradi et al. (2011) proposes that it comes from the irradiated zone in close binary systems, NGC 6326 is an unambiguous example (Miszalski et al. 2011). However, the wels are probably a heterogeneous group of stars, and certainly not all of them are binary systems. On the other hand, the nebular contamination might lead to an incorrect classification; i.e., some Of stars may have key absorption lines filled in by the nebular emission and may be classified as wels instead.

The H-poor CSPN can also display spectra with absorption lines (sometime dominated by them), named as PG 1159, [WC]-PG1159, O(He)[3], and DO. In addition, there is a small group of stars with the characteristics of the PG 1159 stars, but they also show hydrogen absorption lines. These objects are called hybrids-PG1159 stars (Napiwotzki & Schönberner 1991). It is important to mention that some spectral types also found in the literature are currently included in the classification scheme described above, such as: Of-WR(C) into [WC]-PG1159, O(C) into PG 1159, and Of-WR(H) into wels.

3.2. Classification and criteria

Whenever possible, we have tried to determine the spectral types of our CSPN sample. For all those showing a stellar continuum with H or He absorption lines, we tried to carry out a spectral classification in the MK system. This was done by taking the spectral types from the Atlas of Walborn & Fitzpatrick (1990). For PNe with H-poor cores (i.e., with [WR]-type central stars), we followed the criteria defined by TA1993 and Acker & Neiner (2003, Table 2). This classification is based on the *FWHM* and dereddened strength with respect to the continuum of several emission lines. Concerning wels, as stated above, there is no robust quantitative criterion leading to any certainty in the classification. However, we used the work of TA1993 (their Table 6), which is based on dereddened lines at λ 4650 Å and C IV 5806 Å.

Our spectral classifications are presented in the third column of Table 1. The *FWHM* and W_λ of the emission lines used to derive those classifications are listed in Table 2. The spectra of the classified CSPN are shown in Figs. 2–13 (sorted by spectral types). In the case of emission-line stars, we preferred to show only the spectral range where the more intense lines are located.

For those spectra where quantitative classification was not possible, the presence of C IV λ5806 and the absence of C III λ5696 resulted in a "wels" type. The detection of the C III line indicates a [WC]. Finally, eight CSPN were tagged as "wels?" because the lines of C IV 5806 Å and C III 5696 Å are absent (or very weak), but we detected the complex at 4650 Å. In all these cases we could identify C IV 4658 Å and He II 4686 Å.

[1] IRAF: the Image Reduction and Analysis Facility is distributed by the National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc. (AURA) under cooperative agreement with the National Science Foundation (NSF).

[2] Méndez (1991) included in the type hgO(H) the spectral type DA, DAO, and sdO.

[3] See Rauch et al. (1998).

Table 1. Spectral types from our observations.

Name	PN G	S.T.
H 1-62	000.0−06.8	[WC10-11]
PC 12	000.1+17.2	early O
IC 4634	000.3+12.2	wels
H 1-63	002.2−06.3	O?
IC 5148	002.7−52.4	O?
Ap 1-12	003.3−04.6	peculiar
M 1-53	015.4−04.5	wels?
Sa 1-8	020.7−05.9	O
NGC 6790	037.8−06.3	wels
A 14	197.8−03.3	B8-9
K 2-2	200.1+04.7	early O
M 1-6	211.2−03.5	[WC10-11]?
DeHt 1	228.2−22.1	K0-4e
SaSt 2-3*	232.0+05.7	B
M 1-11	232.8−04.7	[WC10-11]
M 1-14	234.9−01.4	O
M 1-12	235.3−03.9	[WC10-11]
Y-C 2-5	240.3+07.0	wels
M 4-2	248.8−08.5	wels
M 3-6	253.9+05.7	wels
PB 2	263.0−05.5	wels?
PB 4	275.0−04.1	wels?
IC 2501	281.0−05.6	wels
IC 2553	285.4−05.3	wels?
He 2-47	285.6−02.7	[WC10-11]
IC 2621	291.6−04.8	wels
He 2-97	307.2−09.0	wels
He 2-105	308.6−12.2	early O
NGC 5307	312.3+10.5	wels
He 2-107	312.6−01.8	[WC10-11]
PHR1416-5809	313.9+02.8	[WC9]
He 2-434	320.3−28.8	O
NGC 5979	322.5−05.2	wels
He 2-128	325.8+04.5	wels?
WRAY 17-75	329.5−02.2	early O
He 2-187*	337.5−05.1	O5 ((f))
NGC 6026	341.6+13.7	O7
Sp 3	342.5−14.3	early O
PC 17	343.5−07.8	wels
Cn 1-3	345.0−04.9	wels?
IC 4663	346.2−08.2	wels?
IC 4699	348.0−13.8	wels
NGC 6337	349.3−01.1	wels
H 1-35	355.7−03.5	wels?
M 1-27*	356.5−02.3	peculiar
Te 2022	358.8+00.0	early B

Notes. The PN are denoted by their common name and by their PN G designation. Posible PNe are marked by: *. The third column lists the spectral-type that we have adopted for each CSPN.

Some wels do not have emission at C IV; see Marcolino & de Araújo (2003).

The equivalent width and *FWHM* measured in our spectra are much lower than those published by TA1993, perhaps because of the low S/N of our spectra. However, the *FWHM* of the nebular emission line is ~9 Å, indicating that the lines shown in Table 2 in fact belong to the stars. On the other hand, taking the mean wavelength of the blend at 4650 Å into account, we could confirm that the principal contributing element in the wels is N, as was shown by TA1993.

3.3. Notes on some individual CSPN

IC 4634 (PN G000.3+12.2): wels. Emission lines of C IV at 5801–11 Å seem to be resolved, suggesting narrow lines. Also, the emission blend C III + C IV at 4654 Å is present. In addition, we observe absorption lines of He II at 4541 Å. Although we cannot rule out an Of spectral type, since a weak emission at 5806 can be observed in very early O-type stars, e.g. in the spectrum of HD 93129A (private spectrum of Gamen), the strong emissions of C IV suggest a wels rather than an Of star. This object was previously classified as continuous by Hyung et al. (1999) and Feibelman (1994).

IC 5148 (PN G002.7−52.4): O?. We were able to minimize the nebula contamination and to identify the absorption lines of the Balmer series and He II 4686 Å (the later confirming an O-type spectrum). Méndez (1991) classified this star as hgO(H). Nevertheless, IC 5148 does not seem to be an evolved object.

Ap 1-12 (PN G003.3−04.6): peculiar. We identify absorption lines of He I $\lambda\lambda$ 4387, 4471, 4920, and 5876 Å, He II 5412 Å (weak), C III 4650 Å, and C IV 5806. Moreover, the emission line of C III 5696 Å is noticeable, and there is no evidence of C II. Górny et al. (2009) classify this star as a [WCL], based on the detection of C III 5696 Å. Ap 1-12 is spectroscopically similar (except for the lack of C II) to the peculiar CSPN IRAS 21282+5050 (Acker & Neiner 2003; Crowther et al. 1998).

A 14 (PN G197.8−03.3): B8-9. In this spectrum the Balmer series is clearly visible in absorption. Along with the lack of Ca II 3933 Å and He I absorption lines, this seems to indicate a late B spectral type. This star was classified as B5 III-V by Lutz & Kaler (1987), according to its dereddened colors. Such a cool spectral type cannot explain the high ionization of the nebula (Bohigas 2003), so it must be a binary system.

K 2-2 (PN G204.1+04.7): early O. We note the presence of the Balmer lines and strong He II lines at 4686 Å and 5412 Å, whereas there is no sign of He I lines. Therefore, we propose an early-O type for this star. Napiwotzki & Schönberner (1995) classify it as hgO(H).

M 1-6 (PN G211.2−03.5), M 1-11 (PN G232.8−04.7) and M 1-12 (PN G235.3−03.9): The emission-line nature of these stars was first noted by Kondrat'eva (1994). However, she did not classify the stars.

DeHt 1 (PN G228.2−22.1): K0-4e. The most important feature is the very strong Hα emission. We took several echelle spectra of this CSPN and observed that the emission line is double and its radial velocity variable. While Bond et al. (1989) did not mention Hα emission, they commented on the strong Mg II and Ca II emission, which could arise from a fast-rotating cool component in a binary system. We do not detect the H and K lines in emission, so they may be variable. We would like to point out the absorption lines of the CH G-band λ4300 and Na I λ5892 (Fig. 5).

SaSt 2-3 (PN G232.0+05.7): B. Absorption lines He I 4920 Å and 4713 Å (weak) and C III 4650 Å (strong) are observed. There are also hints of Si IV 4089 Å and 4116 Å. Kohoutek (1997) suggest this could be a PPN. Pereira & Miranda (2007) note He absorption lines and an absorption line that they suggest is due to C IV at 4658. Stellar absorption lines were also seen in the spectrum presented by Dopita & Hua (1997). This object deserves more detailed studies.

M 3-6 (PN G253.9+05.7): wels. He II absorption lines are observed at 4200 and 4541 Å and possibly 5412 Å. A strong emission of C IV 5806 Å is seen, as is the typical group of wels emission lines around 4650 Å. But, as in the case of IC 4634, an

Table 2. Measurements of the strongest stellar emission lines used to classify our sample of [WC] and wels CSPN.

Name	PN G	Sp. Type	Equivalent width [Å]			*FWHM* [Å]			*I*(4650)	*I*(4686)
			4650	5696 (C iii)	5806 (C iv)	4650	5696 (C iii)	5806 (C iv)	[*I*(5806) = 100]	[Hβ = 100]
IC 4634	000.3+12.2	wels	6 C	–	3	22	–	23(d)	340	0.4
NGC 6790	037.8−06.3	wels	23 N	–	2	18	–	19(d)	>1000	5.0
Y-C 2-5	240.3+07.0	wels	2 N	–	3	19	–	21(d)	80	55.0
M 4-2	248.8−08.5	wels	29 N	–	7:	30	–	18:	550	85.0
M 3-6	253.9+05.7	wels	5 N	–	7	25	–	20	206	3.6
IC 2501	281.0−05.6	wels	10 N	–	8	22	–	23	180	–
IC 2621	291.6−04.8	wels	93 N	–	5	15	–	18	>1000	39.0
He 2-97	307.2−09.0	wels	15 C	–	8	22	–	19	290	2.0
NGC 5307	312.3+10.5	wels	4 N	–	2	16	–	16	570	43.0
NGC 5979	322.5−05.2	wels	17 N	–	5:	20	–	18:	590	107.0
PC 17	343.5−07.8	wels	6 N	–	+	22	–	+	–	2.0
IC 4699	348.0−13.8	wels	8 N	–	2:	23	–	12:	450	25.0
NGC 6337	349.3−01.1	wels	9: N	–	5	50:	–	19	210	–
M 1-53	015.4−04.5	wels?	+ N	–	+	+	–	+	–	3.6
PB 2	263.0−05.5	wels?	11 N	–	–	16	–	–	–	12.5
PB 4	275.0−04.1	wels?	50 N	–	–	17	–	–	–	24.4
IC 2553	285.4−05.3	wels?	64 N	–	?	14	–	?	–	34.5
He 2-128	325.8+04.5	wels?	7 C	–	–	21	–	–	–	0.6
Cn 1-3	345.0−04.9	wels?	8 C	–	–	23	–	–	–	<0.1
IC 4663	346.2−08.2	wels?	48 N	–	?	17	–	?	–	98.6
H 1-35	355.7−03.5	wels?	10 C	–	?	14	–	?	–	<0.1
H 1-62	000.0−06.8	[WC10-11]	6 N	3	+	25	10	+	>1000	–
M 1-6	211.2−03.5	[WC10-11]?	4 C	4:	–	12	29:	–	–	–
M 1-11	232.8−04.7	[WC10-11]	5 N	4	–	29	10	–	–	–
M 1-12	235.3−03.9	[WC10-11]	4: C	3	–	35:	9	–	–	–
He 2-47	285.6−02.7	[WC10-11]	11 C	5	–	28	16	–	–	1.1
He 2-107	312.6−01.8	[WC10-11]	13 N	2	–	24	13	–	–	5.1
PHR1416-5809	313.9+02.8	[WC9]	160 C	238	82	16	20	25	>160	–

Notes. The emission line at 4650 Å is due to C and N. We use the same notation as in TA93 to indicate the dominant ion (fourth column). Also the "+" means that the emission is visible, but its measurement is uncertain; (d) means that it is possible to distinguish two components, i.e. C iv 5801 and 5812 Å.

Of classification cannot be rejected. This object is also classified as wels by Acker & Neiner (2003). Finally, a binary nature could explain this composite spectrum.

PHR 1416-5809 (PN G313.9+02.8): [WC9]. A very recent study by DePew et al. (2011) also classifies this star as [WC9].

NGC 6026 (PN G341.6+13.7): O7. We observe absorption lines of the Balmer series, He i is observed at 4471, 4920, 5876, and 6678 Å, and He ii at 5412, 4686, 4541, 4200, and 4026 Å. Possible absorption of C iii is seen at 4650 Å. The intensities of the lines 4541 and 4471 are comparable, suggesting a type O7. Hillwig et al. (2010) show that this is a close binary.

Sp 3 (PN G342.5−14.3): early O. Balmer lines and He ii 4200 Å, 4541 Å, 4686 Å, and 5411 Å are identified but no He i is present in our spectrum. An emission of C iv 5806 Å is present (see description of M 3-6). Through observations in the UV, Gauba et al. (2001) classify it as O3V and a possible binary.

IC 4699 (PN G348.0−13.8): wels. Gorny et al. (2009) suggest it is a wels by examination of the measured lines tabulated by Wang & Liu (2007).

NGC 6337 (PN G349.3−01.1): wels. The spectrum presents an intense emission of C iv at 5806 Å and another wide emission at 4642 Å. Hillwig et al. (2010) show that this is a close binary. In this case, the wels features may come from an irradiated secondary.

M 1-27 (PNG356.5−02.3): peculiar. This is a very interesting object, because we observed absorption lines of O iii at 5592 and He ii at 5412 Å. But there is a clear emission line of C iii at 5696 Å and a lack of C ii. On the other hand, Méndez (priv. comm.) reports other absorption lines, such as C iv λ5806, He ii λ4686, and Hγ. Such characteristics are observed in the nucleus of the PNe K 2-16, IRAS 21282+5050, and Ap 1-12 (see description of this spectrum). Górny et al. (2004) classify it as a [WC11]?

4. Summary

We are carrying out a spectroscopic survey of PNe from a 2.15-m telescope at CASLEO, Argentina. We performed a quantitative and qualitative determination of the spectral types of 46 of their central stars (plus 6 CSPNe classified as "continuous" in Paper I), most of them previously unclassified. Sixteen of them are OB-type stars, thus substantially increasing their number among CSPN. Also, for a few CSPN we reported some features that could indicate a binary nature, e.g. DeHt 1. Spectroscopic observations at higher spectral resolution are required to obtain more accurate classifications. In particular, the central stars of

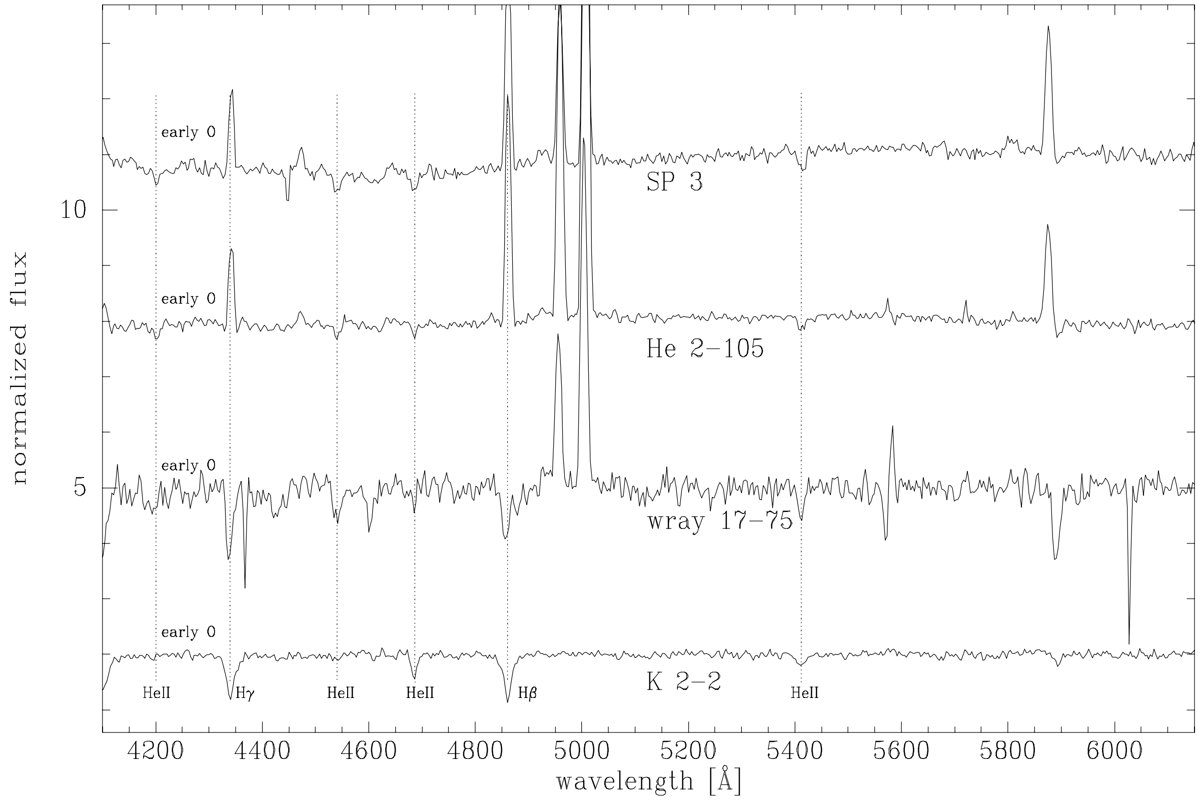

Fig. 2. Normalized spectra of early-O CSPN (see Table 1) grouped according to their spectral classification. The interstellar absorption bands (λ4428; λ5780, and λ5893) are not indicated. The most important spectral features (absorption or emission) identified are He II λ4200, Hγ, He II λ4541, He II λ4686, Hβ, and He II λ5412.

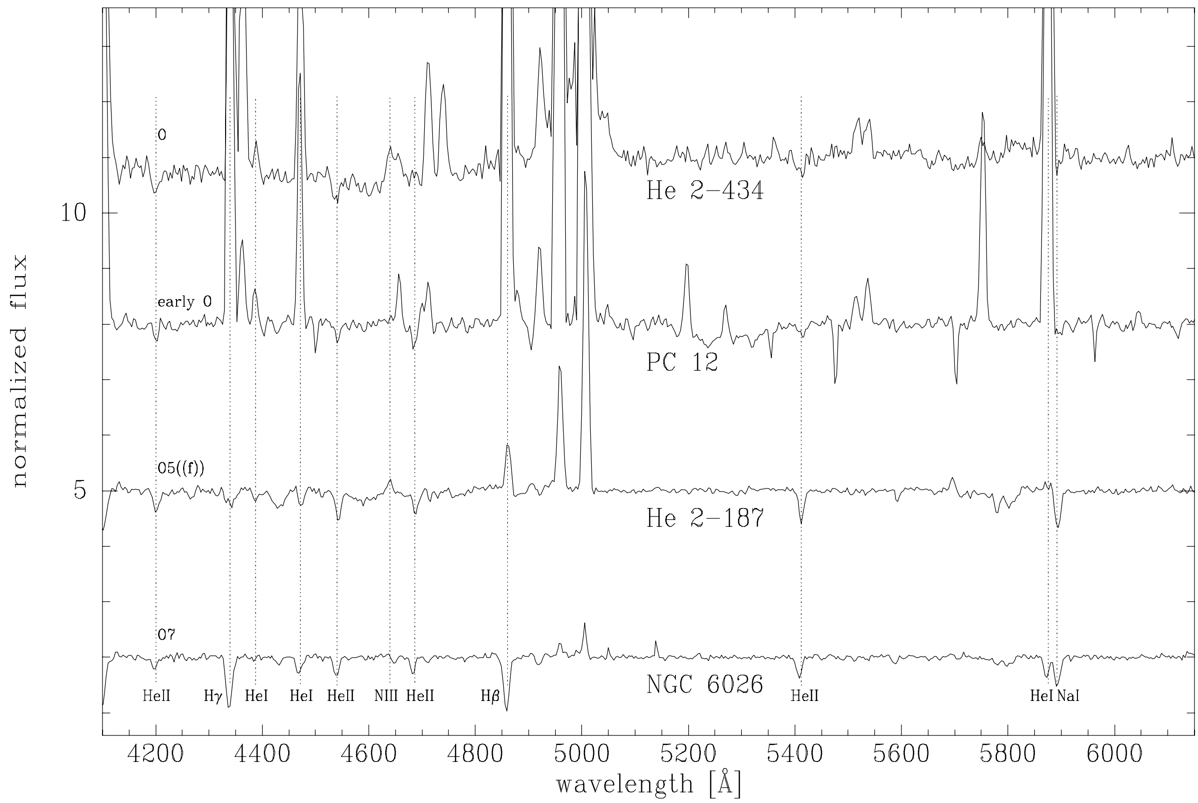

Fig. 3. Normalized spectra of O-type CSPN. As in Fig. 2, the most important spectral lines are identified, plus He I lines at 4387, 4541, and 5876 Å. In addition, the interstellar line of NaI is indicated. Nebular emission was removed in the spectra of NGC 6026.

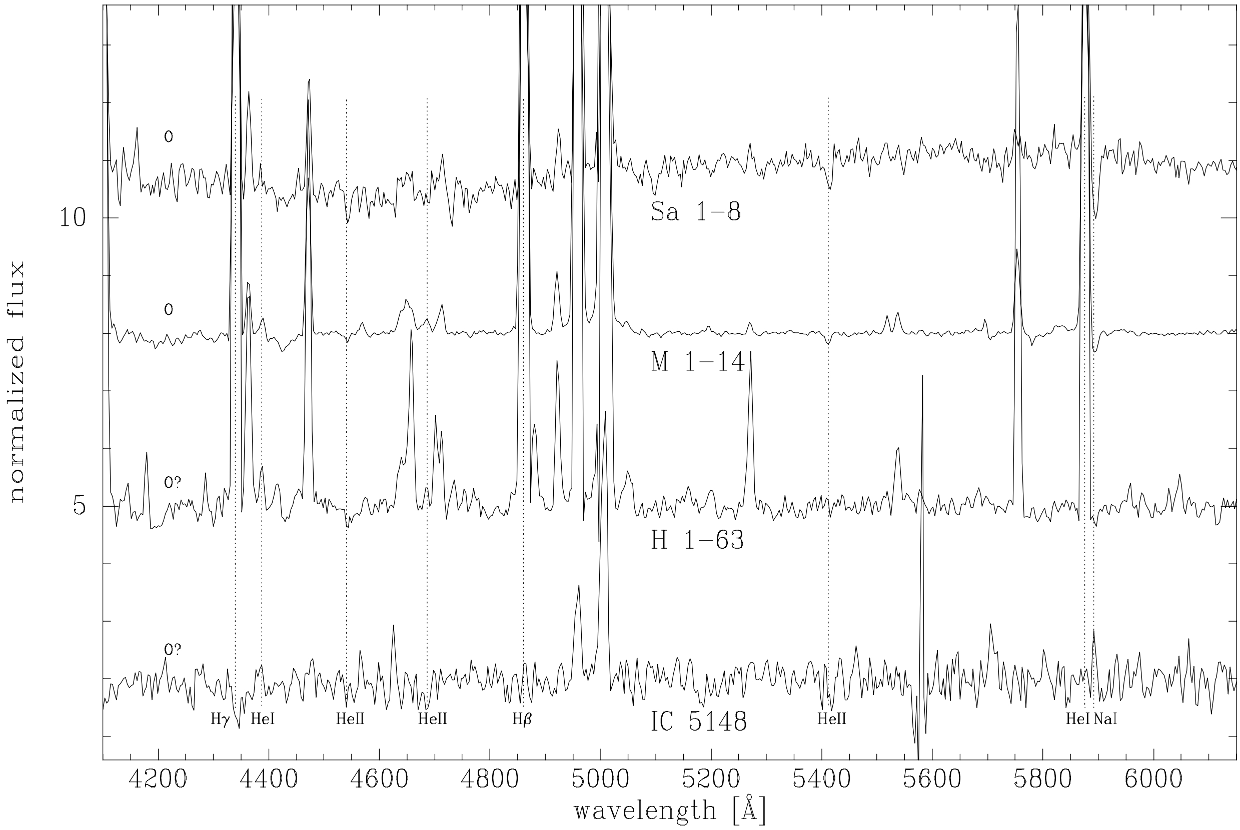

Fig. 4. Normalized spectra of O-type CSPN. Absorption lines of He II are observed in the spectra. The interstellar line of NaI is indicated.

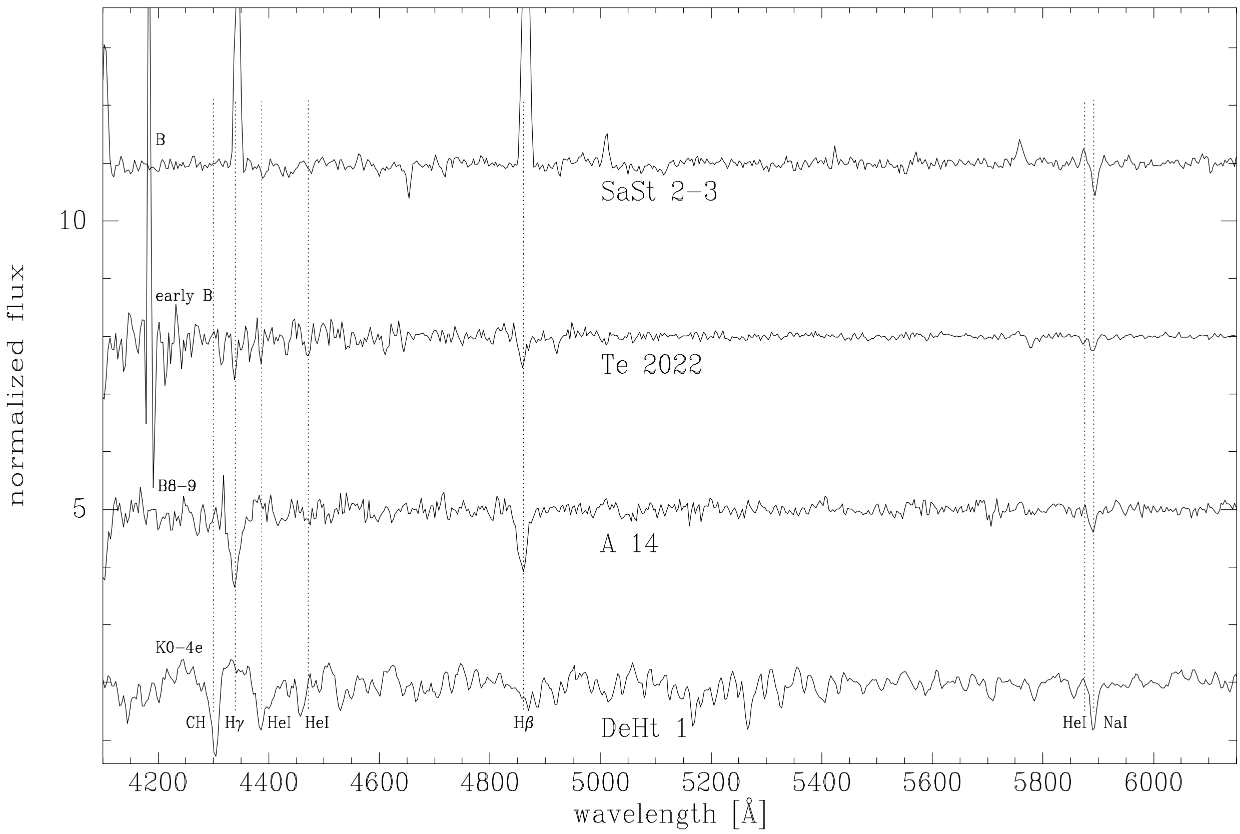

Fig. 5. Normalized spectra of B-type CSPN, plus DeHt 1. He I is not observed, but He I are noticeable, suggesting a B type.

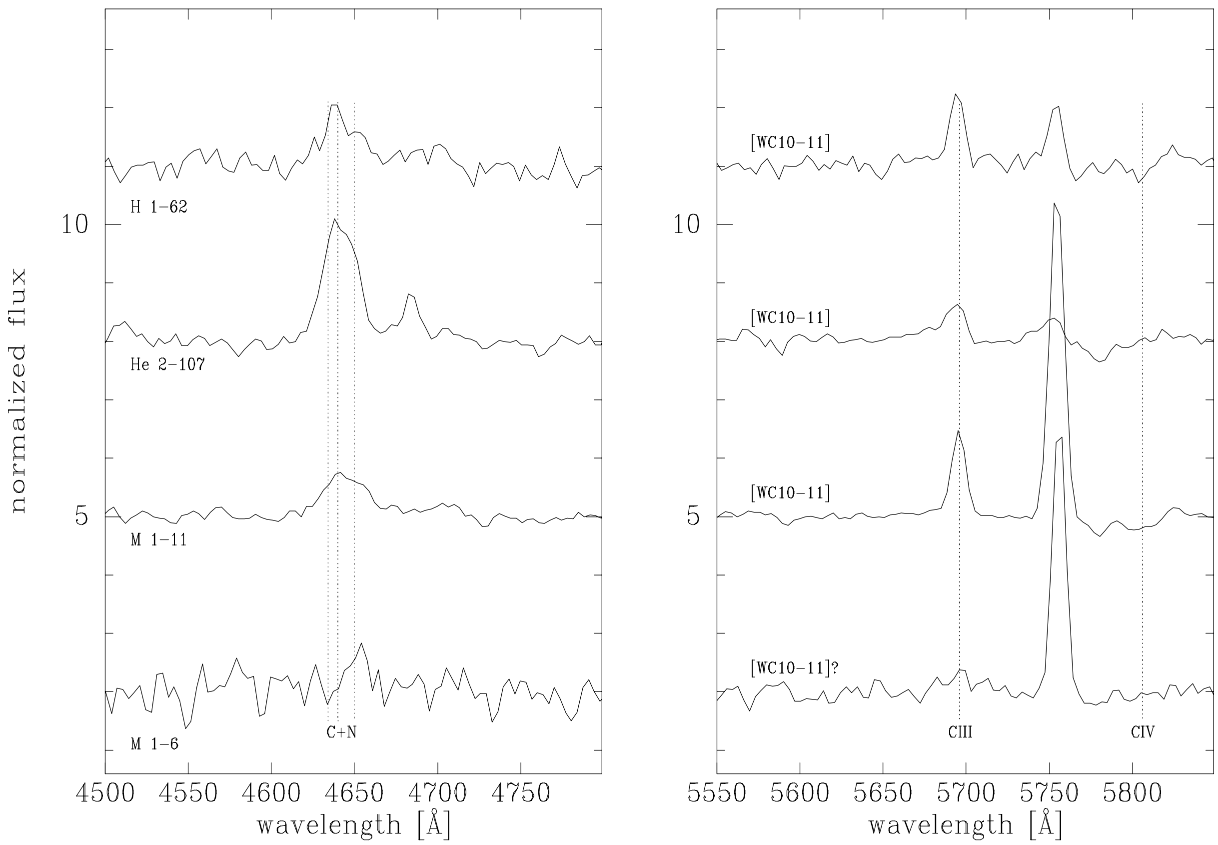

Fig. 6. Normalized spectra of [WC] CSPN. The three lines indicated by C+N are N III λ4634, N III λ4640, and C III λ4650.

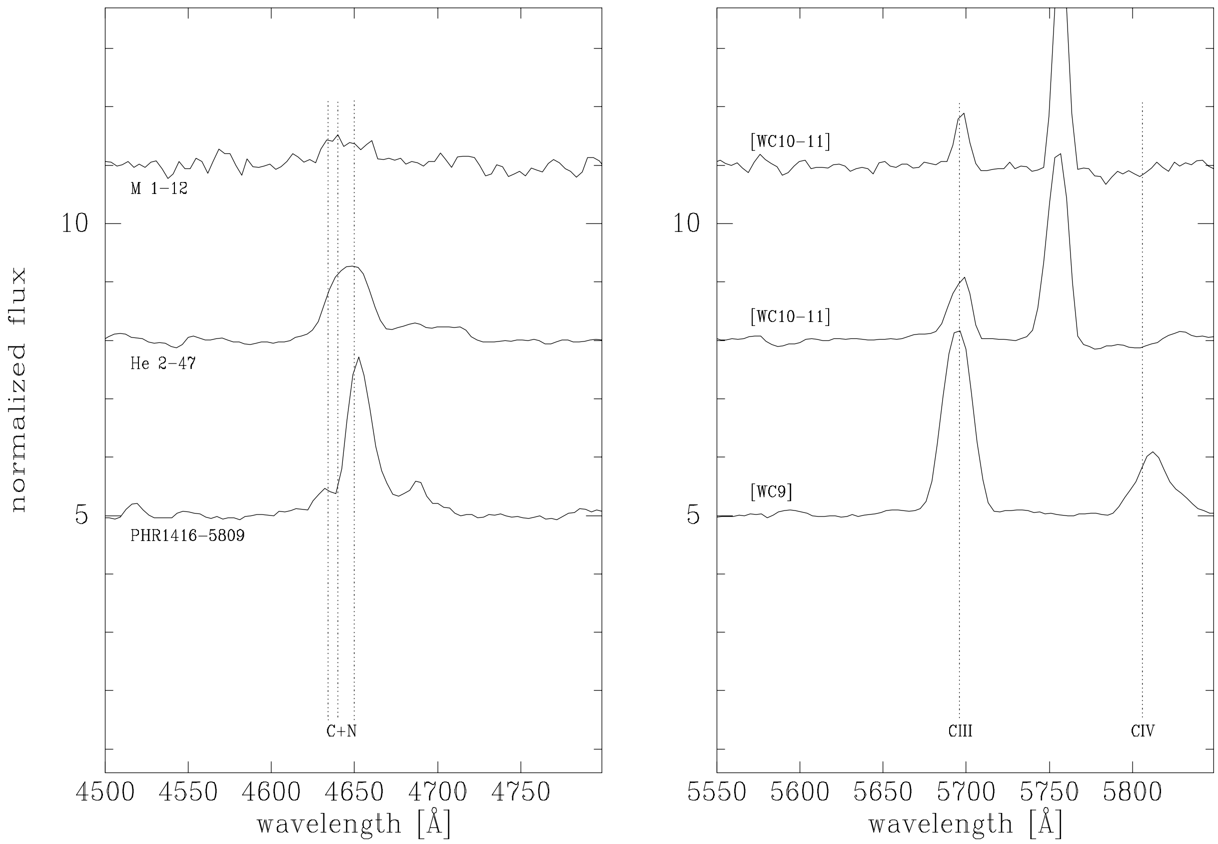

Fig. 7. Normalized spectra of [WC] CSPN.

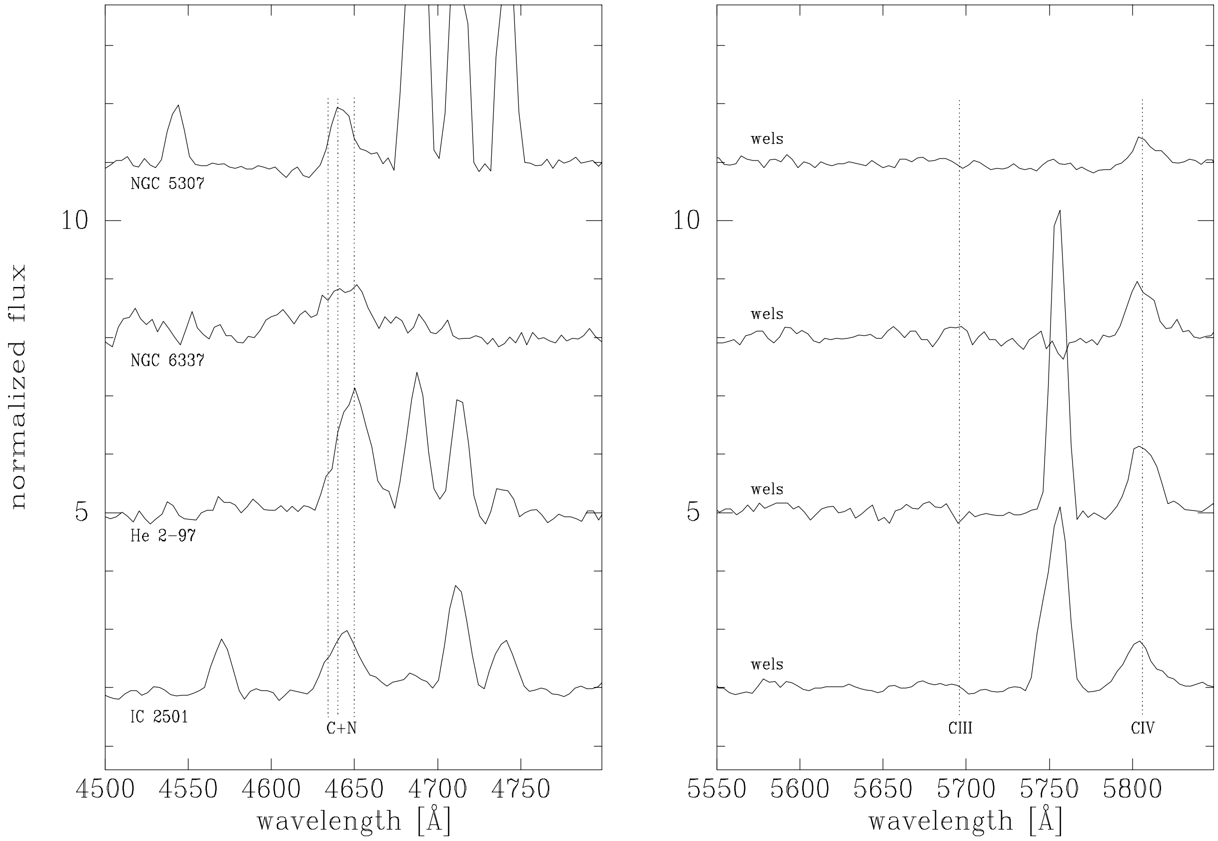

Fig. 8. Normalized spectra of wels CSPN.

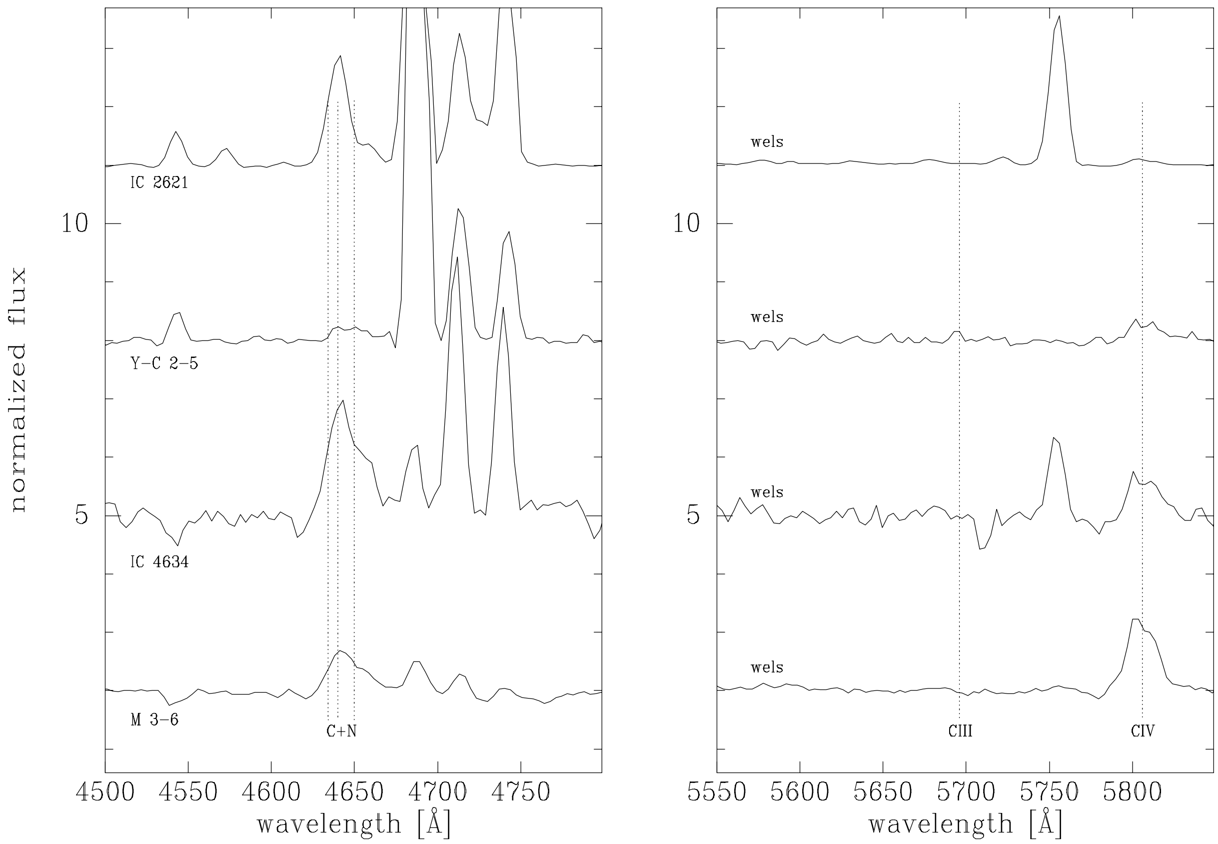

Fig. 9. Normalized spectra of wels CSPN, with He II λ4541 in absorption in the spectra of IC 4634 and M 3-6.

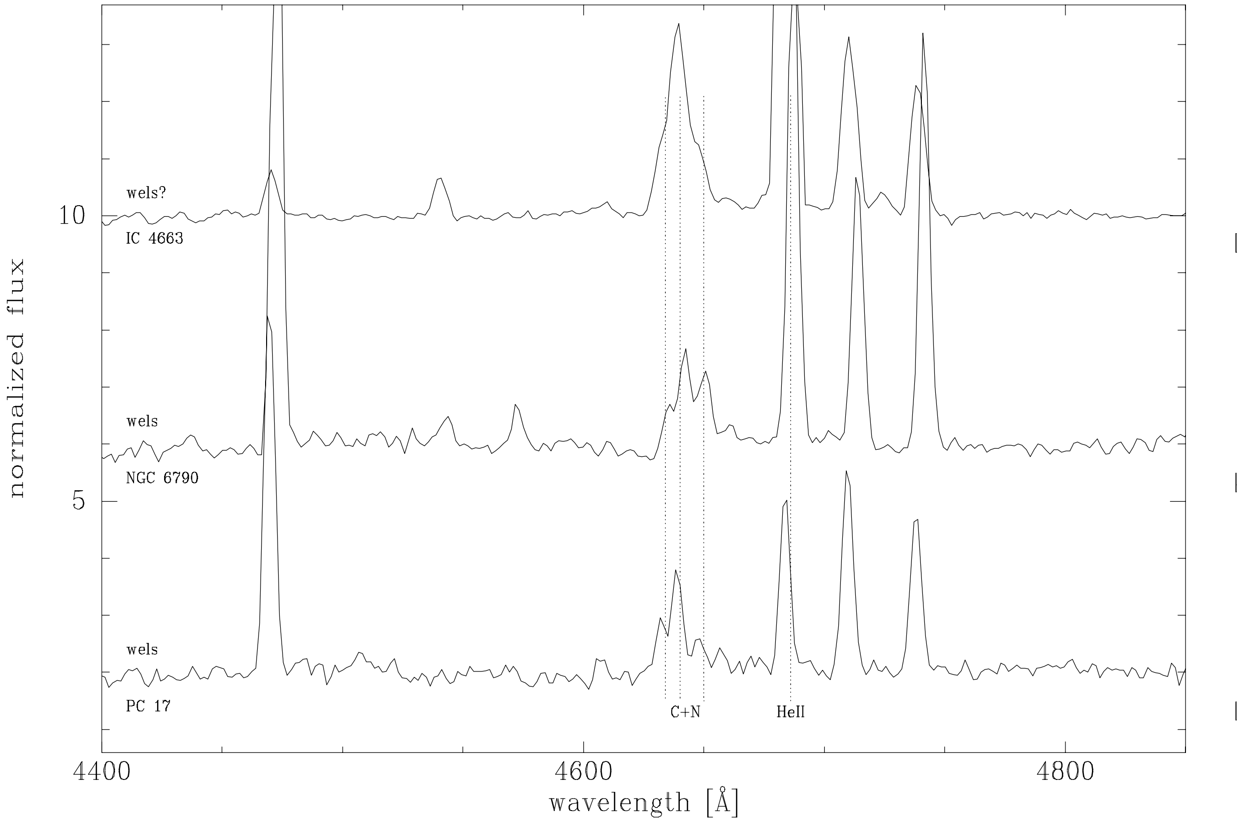

Fig. 10. Normalized spectra of wels CSPN, but observed with the 600 line mm^{-1} grating.

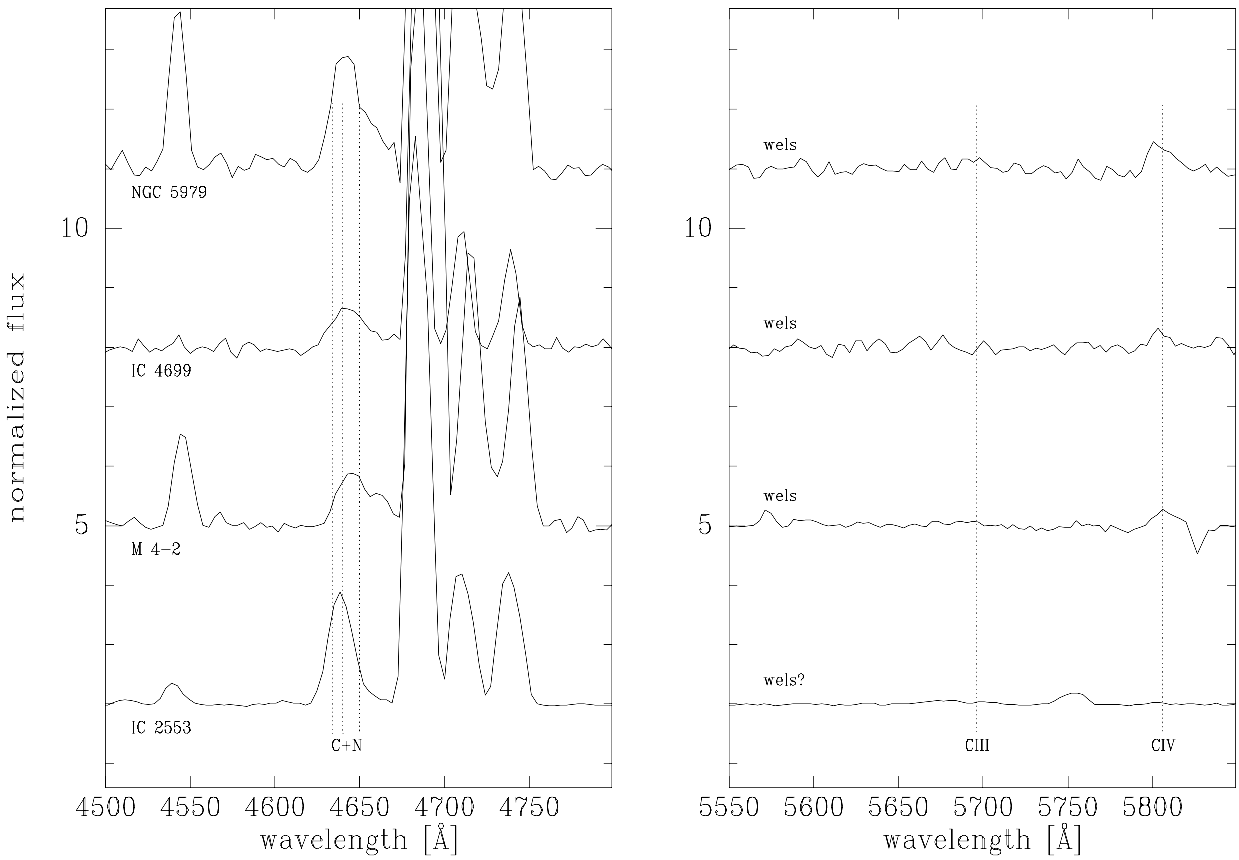

Fig. 11. Normalized spectra of wels CSPN.

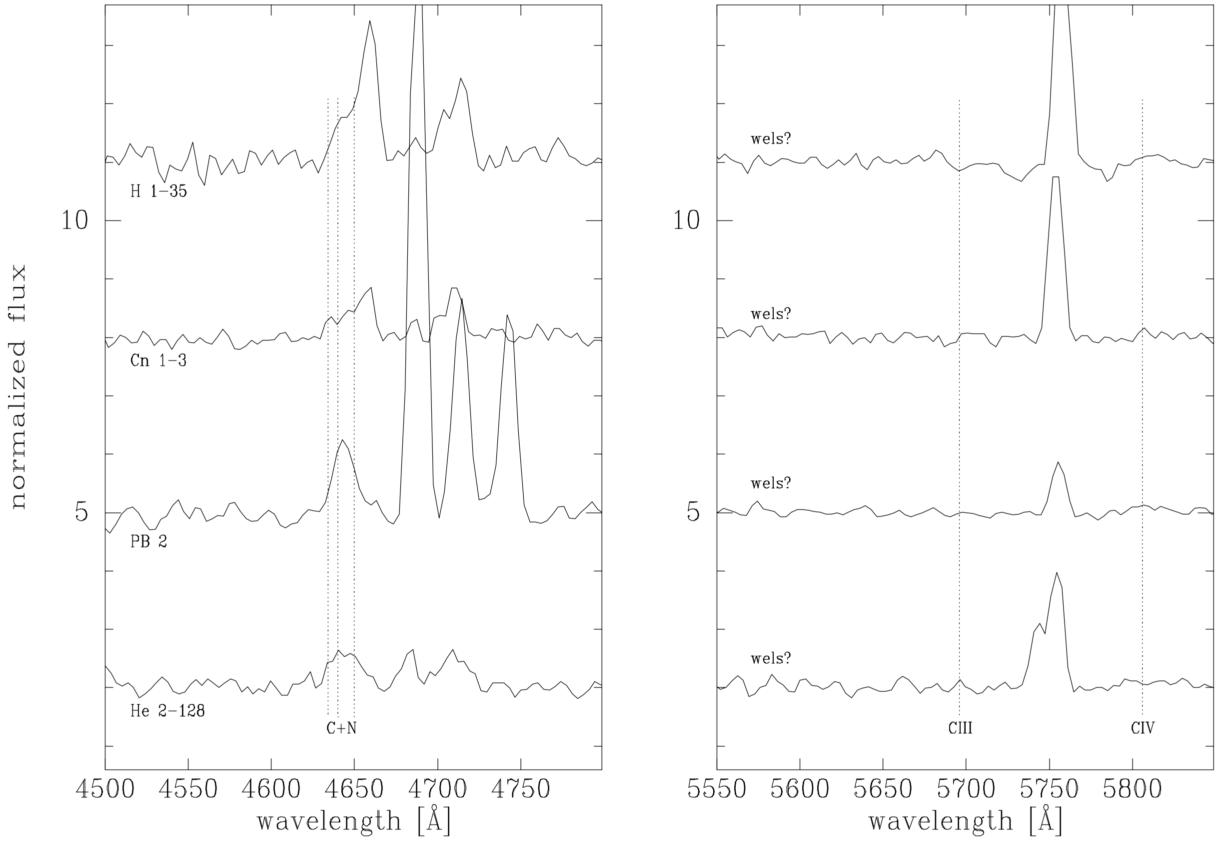

Fig. 12. Normalized spectra of "wels?" CSPN. The unique noticeable feature is the emission at 4650 Å. This emission in the spectrum of H 1-35 and CN 1-3 seems to be dominated by C IV 4658 Å.

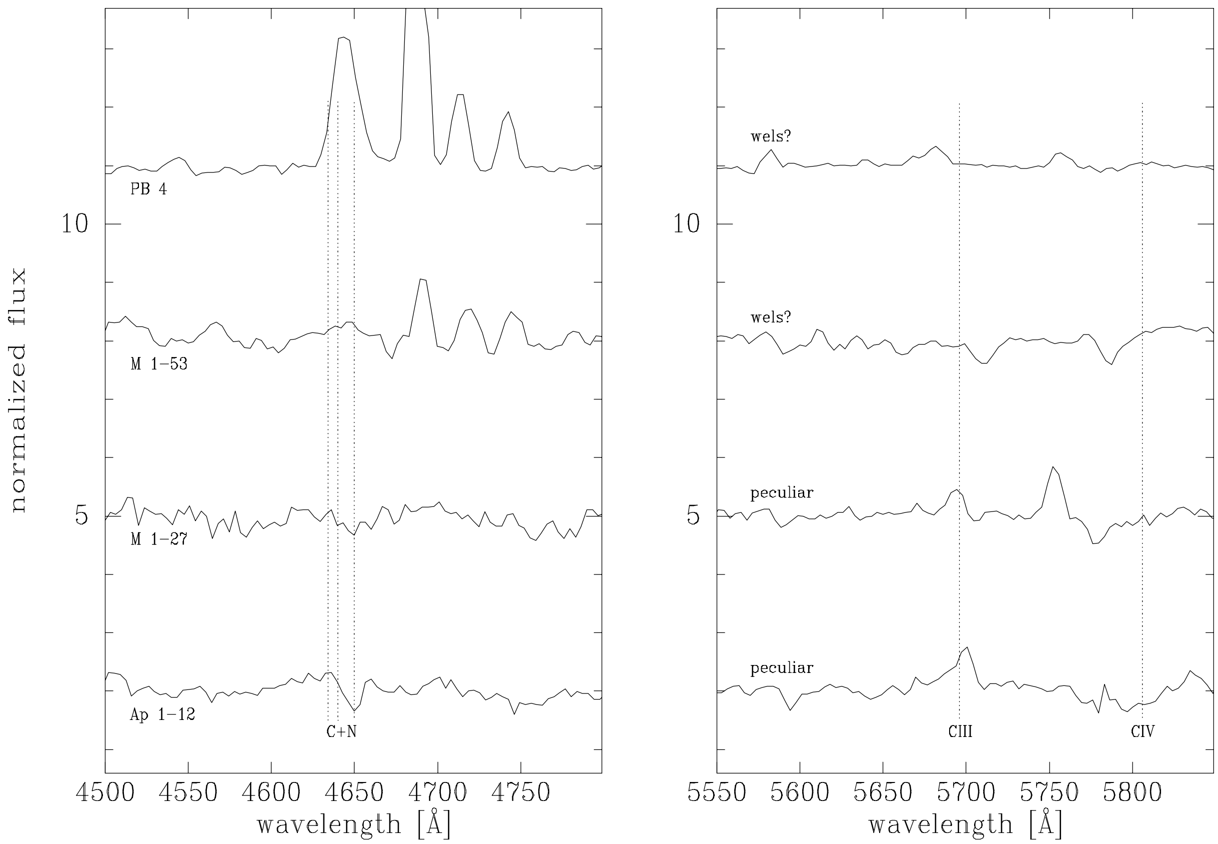

Fig. 13. Normalized spectra of other CSPN.

Table 3. Spectrophotometric standard stars observed to flux calibrate each of our spectra.

Object	Runs	STD 1	STD 2	STD 3
IC 5148	Nov. 2005	LTT 377	LTT 3218	LTT 9239
He 2-107	Mar. 2006	LTT 3864	CD-32.9927	–
He 2-47	Mar. 2006	LTT 3864	CD-32.9927	–
Te 2022	Mar. 2006	LTT 3864	–	–
M 1-14	Mar. 2006	LTT 3864	–	–
IC 2621	Mar. 2006	LTT 3864	–	–
M 1-11	Mar. 2006	LTT 3864	–	–
Sp 3	Aug. 2006	LTT 7379	LTT 7987	LTT 377
He 2-434	Aug. 2006	LTT 7379	LTT 9491	–
DeHt 1	Sep. 2006	LTT 9239	LTT 1020	–
A 14	Sep. 2006	LTT 9239	LTT 9491	–
M 1-53	Sep. 2006	LTT 9239	–	–
SaSt 2-3	Nov. 2006	LTT 1020	–	–
M 4-2	Nov. 2006	EG 21	–	–
PB 4	Apr. 2007	HR 3454	HR 4468	HR 5501
He 2-105	Apr. 2007	HR 3454	HR 4468	HR 5501
PC 12	Apr. 2007	HR 3454	HR 4468	HR 5501
He 2-97	Apr. 2007	HR 3454	HR 4468	HR 5501
M 1-12	Apr. 2007	HR 3454	HR 4468	HR 5501
M 1-6	Apr. 2007	HR 3454	HR 4468	HR 5501
PB 2	Apr. 2007	HR 4468	HR 5501	–
NGC 6026	Apr. 2007	HR 4468	HR 5501	–
Wray 17-75	Apr. 2007	HR 4468	HR 5501	–
He 2-187	Apr. 2007	HR 4468	HR 5501	–
Y-C 2-5	Apr. 2007	HR 4468	HR 5501	–
K 2-2	Apr. 2007	HR 3454	HR 5501	–
PHR1416-5809	Apr. 2007	HR 3454	HR 5501	–
NGC 6337	Apr. 2007	HR 3454	HR 5501	–
M 3-6	Apr. 2007	HR 3454	HR 5501	–
NGC 5307	Jul. 2007	HR 4963	HR 7950	–
M 1-27	Jul. 2007	HR 4963	HR 7950	–
NGC 5979	Jul. 2007	HR 4963	HR 7950	–
H 1-35	Aug. 2007	HR 7950	HR 9087	HR 718
IC 4634	Aug. 2007	HR 7950	HR 9087	HR 718
Cn 1-3	Aug. 2007	HR 7950	HR 9087	HR 718
H 1-62	Aug. 2007	HR 7950	HR 9087	–
Sa 1-8	Aug. 2007	HR 5501	HR 7596	HR 8634
H 1-63	Aug. 2007	HR 7950	–	–
Ap 1-12	Aug. 2007	HR 7950	–	–
He 2-128	May. 2008	HR5501	HR 7596	HR 7950
IC 2501	May. 2008	HR5501	HR 7596	HR 7950
IC 4699	May. 2008	HR5501	HR 7596	HR 7950
IC 2553	May. 2008	HR5501	HR 7596	HR 7950
PC 17	Aug. 2008	HR 7596	–	–
NGC 6790	Aug. 2008	HR 5501	HR 7596	–
IC 4663	Aug. 2008	HR 5501	HR 7596	–

Ap 1-12 and M 1-27, whose spectra are similar to those of the rare objects K 2-16 and IRAS 21282+5050, which do not have a reliable classification.

With this paper, we complete the description of the sample of CSPN presented in Paper I. We hope that the spectroscopic data presented here will provide a guide for future observations, thus contributing to a better understanding of the final stages of stellar evolution.

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References

Acker, A., & Neiner, C. 2003, A&A, 403, 659
Acker, A., Jasniewicz, G., Köppen, J., & Stenholm, B. 1989, A&AS, 80, 201
Acker, A., Marcout, J., Ochsenbein, F., Stenholm, B., & Tylenda, R. 1992, Strasbourg-ESO catalogue of galactic planetary nebulae (Garching: European Southern Observatory)
Bohigas, J. 2003, RMxAA, 39, 149
Bond, H. E., Ciardullo, R., & Meakes, M. 1989, BAAS, 21, 789
Corradi, R. L. M., Sabin, L., Miszalski, B., et al. 2011, MNRAS, 410, 1349
Crowther, P. A., De Marco, O., & Barlow, M. J. 1998, MNRAS, 296, 367
DePew, K., Parker, Q. A., Miszalski, B., et al. 2011, MNRAS, 414, 2812
Dopita, M. A., & Hua, C. T. 1997, ApJS, 108, 515
Feibelman, W. A. 1994, PASP, 106, 56
Frew, D. J., & Parker, Q. A. 2010, PASA, 27, 129
Gauba, G., Parthasarathy, M., Nakada, Y., & Fujii, T. 2001, A&A, 373, 572
Górny, S. K., Stasińska, G., Escudero, A. V., & Costa, R. D. D. 2004, A&A, 427, 231
Górny, S. K., Chiappini, C., Stasińska, G., & Cuisinier, F. 2009, A&A, 500, 1089
Hamuy, M., Walker, A. R., Suntzeff, N. B., et al. 1992, PASP, 104, 533
Hillwig, T. C., Bond, H. E., Afşar, M., & De Marco, O. 2010, AJ, 140, 319
Hyung, S., Aller, L. H., & Feibelman, W. A. 1999, ApJ, 525, 294
Kohoutek, L. 1997, A&AS, 125, 445
Kondrat'eva, L. N. 1994, AstL, 20, 644
Lutz, J. H., & Kaler, J. B. 1987, BAAS, 19, 1090
Marcolino, W. L. F., & de Araújo, F. X. 2003, AJ, 126, 887
Méndez, R. H. 1991, IAU Symp., 145, 375
Méndez, R. H., & Niemela, V. S. 1982, IAUS, 99, 457
Minniti, D., Claria, J. J., & Gomez, M. N. 1989, Ap&SS, 158, 9
Miszalski, B., Jones, D., Rodríguez-Gil, P., et al. 2011, A&A, 531, A158
Morgan, D. H., Parker, Q. A., & Cohen, M. 2003, MNRAS, 346, 719
Napiwotzki, R., & Schönberner, D. 1991, A&A, 249L, 16
Napiwotzki, R., & Schönberner, D. 1995, A&A, 301, 545
Paron, S., & Weidmann, W. 2010, MNRAS, 408, 2487
Pereira, C., & Miranda, L. 2007, A&A, 467, 1249
Rauch, T., Dreizler, S., & Wolff, B. 1998, A&A, 338, 651
Todt, H., Peña, M., Hamann, W.-R., & Gräfener, G. 2010a, A&A, 515, A83
Todt, H., Peña, M., Hamann, W.-R., & Gräfener, G. 2010b, ASP Conf. Ser., 1273, 219
Tweedy, R. W., & Napiwotzki, R. 1994, AJ, 108, 978
Tylenda, R., Acker, A., Stenholm, B., & Köppen, J. 1992, A&AS, 95, 337
Tylenda, R., Acker, A., & Stenholm, B. 1993, A&AS, 102, 595
Walborn, N. R., & Fitzpatrick, E. L. 1990, PASP, 102, 379
Wang, W., & Liu, X.-W. 2007, MNRAS, 381, 669
Weidmann, W. A., & Gamen, R. 2011, A&A, 526, A6 (Paper I)