# Central stars of planetary nebulae $\star, \star \star$ 

## II. New OB-type and emission-line stars

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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 ( $\mathrm{PNe} \mathrm{)} \mathrm{are} \mathrm{some} \mathrm{of} \mathrm{the} \mathrm{most} \mathrm{beautiful} \mathrm{objects}$ 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

[^0]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 $2.15-\mathrm{m}$ telescope at CASLEO, Argentina, was employed in this survey. It is equipped with a CCD Tek $1024 \times 1024$ pixels ( $24 \mu \mathrm{~m}$ ) and a read-noise of $7.4 \mathrm{e}^{-1}$ pixel $^{-1}$. A 300 line $\mathrm{mm}^{-1}$ grating, named \#270 and blazed in the blue, was used, and it yielded a dispersion of $3.4 \AA$ pixel $^{-1}$ to the first order (a resolving power $R \approx 2000$ ). On some nights, a grating of 600 line $\mathrm{mm}^{-1}$ (\#260) was used (1.6 $\AA$ pixel $^{-1}$ ). The gratings were used with an unique tilt, giving a typical wavelength range of $3500-7000 \AA(3875-5530 \AA$ with the \#260). The slit was always centered on the CSPN, oriented in the east-west direction and opened to $3^{\prime \prime}$ (consistent with the seeing at the site). The wavelength calibration was performed using $\mathrm{Cu}-\mathrm{Ne}-\mathrm{Ar}$ 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


Fig. 1. The intensity ratios of the $\mathrm{O}_{\text {III }} 4959,5007 \AA$ and the $\mathrm{N}_{\text {II }} 6548$, $6584 \AA$ 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 $\AA$ and [ $\mathrm{N}_{\text {II }}$ ] 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 [ $\mathrm{NIII}^{\prime}$ ] lines, but this is due to the blending of these lines with $\mathrm{H} \alpha$ 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 Of and, to a lesser extent, early B (stars with $T_{\text {eff }}<20000 \mathrm{~K}$ could not ionize the nebula), B[e], sdO, and white dwarfs of the types DA and $\mathrm{DAO}^{2}$.

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 $5696 \AA$ 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 $5806 \AA$ lines (and high excitation O-lines, e.g. O vi $3822 \AA$ ). 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

[^1]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 $5806 \AA$ that is systematically weaker and narrower than for the [WC4-8]. Moreover, $\mathrm{C}_{\text {III }}$ is very weak or else absent in canonical wels. The blend of C and N ions at $4650 \AA$ is also generally detectable in wels (note the emission of C iv at $4658 \AA$ 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, $\mathrm{O}(\mathrm{He})^{3}$, 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 $\lambda 4650 \AA$ and C iv $5806 \AA$.

Our spectral classifications are presented in the third column of Table 1. The $F W H M$ and $W_{\lambda}$ 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 Civ $\lambda 5806$ and the absence of $\mathrm{C}_{\text {III }} \lambda 5696$ resulted in a "wels" type. The detection of the $\mathrm{C}_{\text {III }}$ line indicates a [WC]. Finally, eight CSPN were tagged as "wels?" because the lines of C iv $5806 \AA$ and $\mathrm{C}_{\text {III }} 5696 \AA$ are absent (or very weak), but we detected the complex at $4650 \AA$. In all these cases we could identify C iv $4658 \AA$ and Не $_{\text {II }} 4686 \AA$.

[^2]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 Civ; see Marcolino \& de Araújo (2003).

The equivalent width and $F W H M$ 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 $\sim 9 \AA$, 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 $4650 \AA$ 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 Civ at $5801-11 \AA$ seem to be resolved, suggesting narrow lines. Also, the emission blend $\mathrm{C}_{\text {III }}+$ C Iv $^{\text {IV }} 4654 \AA$ is present. In addition, we observe absorption lines of $\mathrm{He}_{\text {II }}$ at $4541 \AA$. 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 Civ 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 $\mathrm{He} \mathrm{i}_{\text {II }} 4686 \AA$ (the later confirming an Otype spectrum). Méndez (1991) classified this star as $\mathrm{hgO}(\mathrm{H})$. 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 Не г $\lambda \lambda 4387,4471,4920$, and $5876 \AA$, Не II $5412 \AA$ (weak), $\mathrm{C}_{\text {III }} 4650 \AA$, and $\mathrm{C}_{\text {Iv }} 5806$. Moreover, the emission line of $\mathrm{C}_{\text {III }} 5696 \AA$ is noticeable, and there is no evidence of $\mathrm{C}_{\text {II }}$. Górny et al. (2009) classify this star as a [WCL], based on the detection of $\mathrm{C}_{\text {III }} 5696 \AA$. Ap 1-12 is spectroscopically similar (except for the lack of $\mathrm{C}_{\text {II }}$ ) 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 Са II $3933 \AA$ 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 it lines at $4686 \AA$ and $5412 \AA$, 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 $\mathrm{hgO}(\mathrm{H})$.

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 $\mathrm{H} \alpha$ 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 $\mathrm{H} \alpha$ emission, they commented on the strong $\mathrm{Mg}_{\text {II }}$ and $\mathrm{Ca}_{\text {II }}$ 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 $\lambda 4300$ and Na i 15892 (Fig. 5).

SaSt 2-3 (PN G232.0+05.7): B. Absorption lines He I $4920 \AA$ and $4713 \AA$ (weak) and C III $4650 \AA$ (strong) are observed. There are also hints of Siiv $4089 \AA$ and $4116 \AA$. 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 Civ 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 $4541 \AA$ and possibly $5412 \AA$. A strong emission of Civ $5806 \AA$ is seen, as is the typical group of wels emission lines around $4650 \AA$. 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.


Notes. The emission line at $4650 \AA$ 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 $5812 \AA$.

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, $\mathrm{He}_{\mathrm{I}}$ is observed at 4471, 4920, 5876, and $6678 \AA$, and $\mathrm{He}_{\text {II }}$ at $5412,4686,4541,4200$, and $4026 \AA$. Possible absorption of $C_{\text {III }}$ is seen at $4650 \AA$. The intensities of the lines 4541 and 4471 are comparable, suggesting a type 07. Hillwig et al. (2010) show that this is a close binary.

Sp 3 (PN G342.5-14.3): early O. Balmer lines and Не II $4200 \AA, 4541 \AA, 4686 \AA$, and $5411 \AA$ are identified but no $\mathrm{He}_{\mathrm{I}}$ is present in our spectrum. An emission of Civ $5806 \AA$ 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 $5806 \AA$ and another wide emission at $4642 \AA$. 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 $\mathrm{O}_{\text {III }}$ at 5592 and $\mathrm{He}_{\text {II }}$ at $5412 \AA$. But there is a clear emission line of $\mathrm{C}_{\text {III }}$ at $5696 \AA$ and a lack of $\mathrm{C}_{\text {II }}$. On the other hand, Méndez (priv. comm.) reports other absorption lines, such as C iv $\lambda 5806$, He II $\lambda 4686$, and $\mathrm{H} \gamma$. 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 $2.15-\mathrm{m}$ 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

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Fig. 2. Normalized spectra of early-O CSPN (see Table 1) grouped according to their spectral classification. The interstellar absorption bands ( $\lambda 4428$; $\lambda 5780$, and $\lambda 5893$ ) are not indicated. The most important spectral features (absorption or emission) identified are He II $\lambda 4200, \mathrm{H} \gamma$, Не ї $\lambda 4541$, Не ї $\lambda 4686, \mathrm{H} \beta$, and Не ІІ $\lambda 5412$.


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 $5876 \AA$. 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 $\mathrm{He}_{\text {II }}$ are observed in the spectra. The interstellar line of NaI is indicated.


Fig. 5. Normalized spectra of B-type CSPN, plus DeHt 1. He it is not observed, but He i are noticeable, suggesting a B type.
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Fig. 6. Normalized spectra of [WC] CSPN. The three lines indicated by $\mathrm{C}+\mathrm{N}$ are $\mathrm{N}_{\text {III }} \lambda 4634, \mathrm{~N}_{\text {III }} \lambda 4640$, and $\mathrm{C}_{\text {III }} \lambda 4650$.


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

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Fig. 8. Normalized spectra of wels CSPN.


Fig. 9. Normalized spectra of wels CSPN, with $\mathrm{He}_{\text {II }} \lambda 4541$ in absorption in the spectra of IC 4634 and M 3-6.
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Fig. 10. Normalized spectra of wels CSPN, but observed with the 600 line $\mathrm{mm}^{-1}$ grating.


Fig. 11. Normalized spectra of wels CSPN.


Fig. 12. Normalized spectra of "wels?" CSPN. The unique noticeable feature is the emission at $4650 \AA$. This emission in the spectrum of $\mathrm{H} 1-35$ and CN 1-3 seems to be dominated by Civ $4658 \AA$.



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 | - ${ }^{-}$ | - 70 |
| 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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    ** 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
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    ${ }^{2}$ Méndez (1991) included in the type $\mathrm{hgO}(\mathrm{H})$ the spectral type DA, DAO, and sdO.

[^2]:    ${ }^{3}$ See Rauch et al. (1998).

