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LETTER

Letter to the Editor

The identification of the star SPH 2 as a new WN4 star with strong CIV*

C.B. Pereira[1], M.A.D. Machado[2], S.J.C. Landaberry[1], and F. da Conceição[1]

[1] Observatório Nacional, Departamento de Astronomia Galáctica e Extra-Galáctica, Rua Gen. José Cristino, 77. CEP 20921-400. São Cristóvão. Rio de Janeiro-RJ, Brazil

[2] Observatório Nacional, Departamento de Astrofísica, Rua Gen. José Cristino, 77. CEP 20921-400. São Cristóvão. Rio de Janeiro-RJ, Brazil

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Abstract. We report spectroscopic observations of a new Wolf-Rayet star not identified yet. This star is located in our Galaxy, in the Canis Majoris region and was discovered during a southern spectroscopic survey of stars previously identified as Hα emission objects. The star, SPH 2, after Schwartz, Persson & Hamann (SPH) (1990), shows the main characteristics of a WN star and a strong CIV 5808 typical of a WC star. Here, we present some of the main spectroscopic features and discuss a possible subtype classification. We also present line intensities and equivalent widths of the identified transitions.

Key words: Wolf-Rayet: general – Wolf-Rayet: WN stars – emission line stars

1. Introduction

In this work we present spectroscopic observations of the emission line star SPH 2, first recognized as an Hα emission object after a objective prism survey of Schwartz et al., 1990. The equatorial coordinates of SPH 2 are α(1950.0) = $07^h\ 18^m\ 16\overset{s}{.}3$ and δ(1950.0) = -23° 38′ 13.″0. Finding chart is found in Schwartz et al. (1990). This star was discovered as a new nitrogen Wolf-Rayet (WN) star in the framework of the spectroscopy survey of some Hα emission line objects in the southern hemisphere. This survey aims to analyze and classify emission-line stars not yet spectroscopically observed. The V magnitude was derived convolving the calibrated spectra with a V filter profile, giving 15.0.

2. Observations and reductions

Spectroscopic observations was performed using a Boller & Chivens cassegrain spectrograph at 1.52m ESO telescope of La Silla (Chile). A UV-flooded thinned Loral Lesser CCD #39 (2048 x 2048, 15μm/pixel) detector was used.

Table 1. Observation log of SPH 2.

Date	Wavelength range	Exp time (sec)	S/N
1997 Nov 7	3500 Å – 7500 Å	1200	100
1997 Nov 8	3100 Å – 5100 Å	1200	70
1998 Jan 17	3500 Å – 7500 Å	1200	100
1998 Jan 18	3130 Å – 5140 Å	1200	70

Two gratings, with different dispersions, were used. One grating, with 600 l/mm which has a reciprocal dispersion of 1.9 Å pixel^{-1} and with a resolution of 4.6 Å, was used for spectral coverage between 3500 Å and 7500 Å. The other grating, with 1200 l/mm which has a reciprocal dispersion of 1.0 Å pixel^{-1}, with a resolution of 2.0 Å was used for spectral coverage between 3100 Å and 5100 Å. The slit width was 4 arcsec. The slit orientation in the blue range was aligned with the parallactic angle in order to minimize the slit loss due to atmospheric refraction. Table 1 shows the log of observations and the typical S/N noise ratio in the continuum achieved in each observation.

The data were reduced to the linear scale, i.e. wavelength versus flux, using IRAF. The data were treated with the help of the *ccdproc* and *onedspec* tasks of IRAF. We followed the standard procedure consisting of bias subtraction, flat-field normalization and wavelength calibration through a He-Ar lamp. Counts were corrected from atmospheric extinction and calibrated from instrumental chromatic response through observations of standard stars from Oke (1974) and from Hamuy et al. (1994). In the linearized spectra, the line fluxes were measured with the *splot* task and blends were resolved using the *deblend* option. Figs. 1 and 2 show the reduced spectra of our sample. We estimate the errors in the fluxes to be about 20% for weaker lines (line fluxes ≈10 on the scale of Hβ=100) and about 10% for stronger lines. No significant line flux variations was de-

Send offprint requests to: C.B. Pereira

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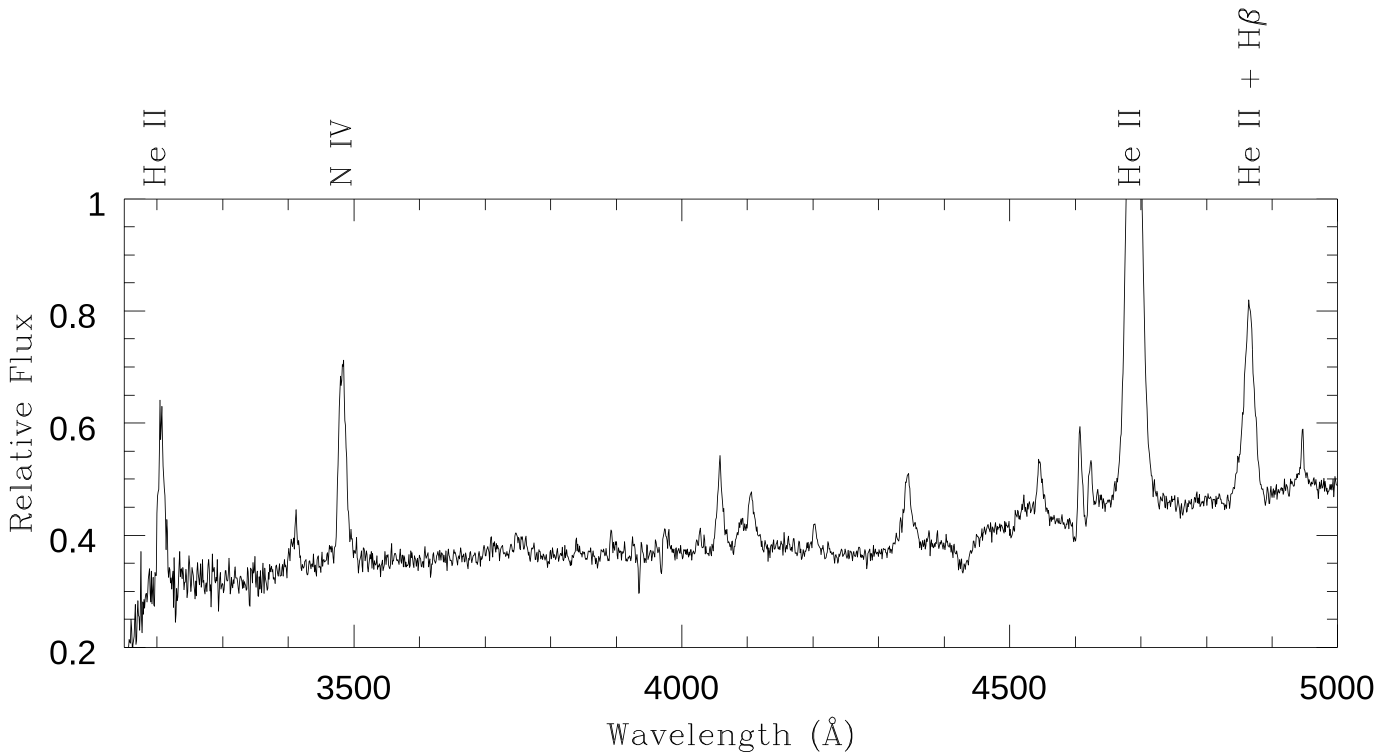

Fig. 1. Blue spectrum of SPH 2. Notice the strength of He II at 4686 Å. Also notice the diffuse absorption band at 4430 Å.

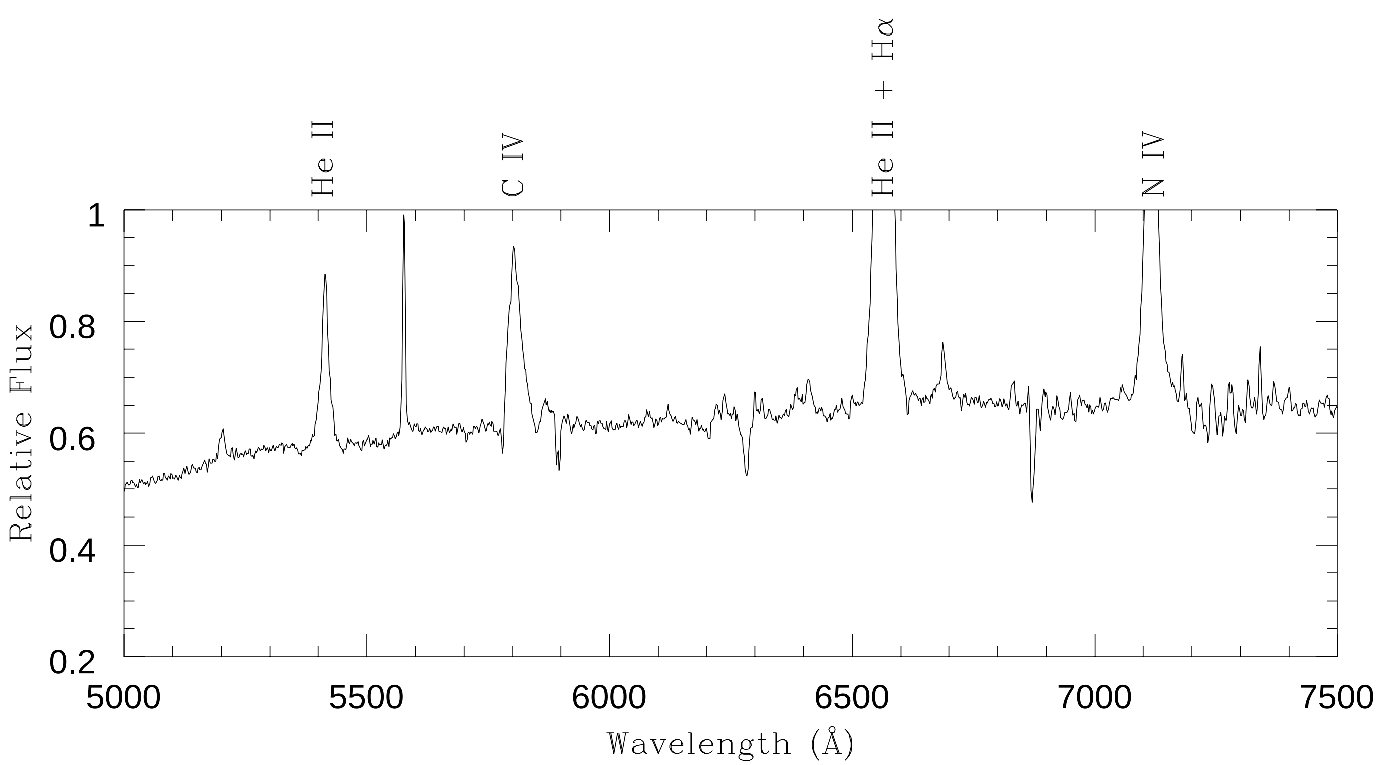

Fig. 2. Optical spectrum of SPH 2. Notice the strength of C IV λ5808 Å. Also notice the diffuse absorption bands at 6284 Å. The emission line at 5577 Å is the night-sky [O I].

tected in our observations performed at November 1997 and at January 1998.

3. The spectra

Table 2 shows the observed line fluxes and the equivalent widths of the identified lines. The spectra of SPH 2 show the main nitrogen lines characterizing a WN star. We can observe the presence of N IV λ4057 Å and N V $\lambda\lambda$4603,4610 Å lines used for WN classification, as well as the strong C IV at 5808 Å line characteristic of WC spectra. As opposed to what is expected for a WN star, the N III at 4640 Å line is absent. Smith et al. (1996) propose a three-dimensional classification for WN stars using the He II 5411/He I 5875 ratio as a primary indicator of ionization. In general, the presence of hydrogen is indicated by an oscillating Pickering decrement. Based on this criteria, SPH 2, is classified as a WN4 with no hydrogen.

In Schwartz et al., 1990, is mentioned that the area of Canis Majoris some stars are close to a dark cloud in Puppis, and also SPH 2. The fact that we see the diffuse absorption bands at 4430 Å and 6284 Å is an indication that this star suffers from strong interstellar extinction. The flux distribution, as given in Figs. 1 and 2, shows that SPH 2 is heavily dust reddened. In order to estimate the magnitude of the extinction we used the statistical relations between equivalent widths and color excess for the absorptions at 4430 Å and 6284 Å, W_λ(4430 Å)≈2.5 E(B-V) and W_λ(6284 Å)≈1.4 E(B-V) (Schmidt-Kaler, 1982). From the equivalent widths of these two lines, given in Table 1, we obtained an E(B-V), respectively, of 1.2 and 2.1.

Other absorption features also observed in our spectra are the interstellar lines of Ca II H and K at 3889 Å and 3933 Å and Na I around 5900 Å. The spectrum between 5000 Å and 7500 Å presents the telluric absorption band of O_2 at 6870 Å.

4. Discussion: a evolutionary status of SPH 2

Conti and Massey (1989) present a spectrophotometric study for nearly all Wolf-Rayet stars in our Galaxy and in the Large Magellanic Cloud. They present a list of some WN stars that shows C IVλ5808 Å stronger than a normal WN star. In their Fig. 5, the logarithm of the equivalent width of C IVλ5808 Å *versus* the logarithm of the equivalent width of He IIλ4686 Å shows a clear difference between normal WN stars and WN/WC stars. Here, we reproduce their plot (Fig. 3) with a inclusion of SPH 2. We can see that SPH 2 occupies the locus halfway of the two groups. This indicates that SPH 2 lies in a transition stage between WN and WN/WC. This scenario will be further investigated with an atmospheric model including nitrogen and carbon lines in a following paper.

5. Conclusions

We presented an identification of SPH 2 (Schwartz, Persson & Hamann, (SPH) (1990)) as a new membership of group of WN stars. This star lies close to the dark cloud in Puppis and its flux distribution, which slowly increases towards the red, indicates that is heavily reddened.

Table 2. Observed emission line fluxes relative to $H\beta = 100$ and equivalent widths.

λ	Ion	Line Flux	W_λ(Å)
3204	He II	5.0	13.0
3410	O IV	1.9	4.3
3482	N IV	6.3	14.1
4058	N IV	26.8	5.4
4101	Hδ+He II	27.6	5.5
4200	He II	11.7	2.3
4340	Hγ+He II	36.1	6.7
4542	He II	30.0	5.0
4605	N V	16.2	2.6
4623	N V	21.4	3.3
4686	He II	522.5	79.6
4861	Hβ+He II	100.0	15.0
4944	N V	13.5	2.0
5202	N IV	15.1	2.0
5411	He II	94.4	12.0
5808	C IV	150.7	17.9
5876	He I	24.8	3.0
6563	Hα+He II	704.2	78.7
6687	He II	22.3	2.4
6831	He II	9.6	1.1
7117	N IV	298.6	33.0
W_λ(4430 Å)	—	—	3.1
W_λ(6284 Å)	—	—	2.9

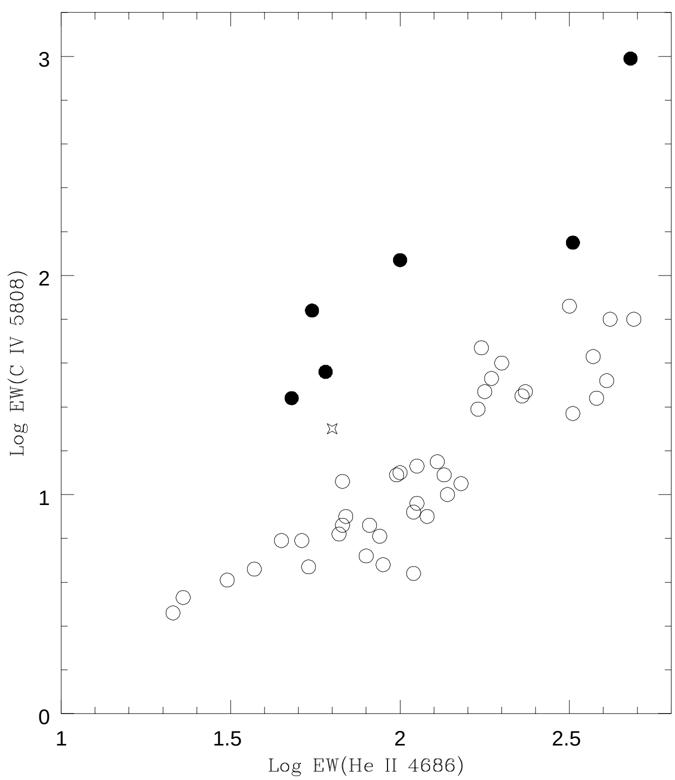

Fig. 3. Log of equivalent width of He II 4686 *versus* log of equivalent width of C IV 5808 as given by Conti and Massey (1989). Empty circles represent galactic WN stars and full circles WN/WC stars. SPH 2 is the star in the middle of the diagram.

From the He II5411/He I5875 ratio we classify SPH 2 as a WN4 star using the classification proposed by Smith et al. (1996). The results shows that SPH 2 has no hydrogen. Finally the presence of the strong C IVλ5808 is investigated and we conclude that SPH 2 is a WN star evolving toward a WN/WC star.

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References

Conti, P., Massey, P., 1989, ApJ, 337, 251.
Smith, L., Shara, M., Moffat, A., 1996, MNRAS, 281, 163.
Hamuy, M., Suntzeff, N. B., Heathcote, S. R., Walker, A. R., Gigoux, P. and Phillips, M. M., 1994, PASP, 106, 566.
Schmidt-Kaler, Th. 1982, in *Landolt Börnstein*, New Series, Group IV, Vol. 2b, (Springer) p.60.
Schwartz, R.D., Persson, S. E. & Hamann, F. W., 1990, AJ, 100, 793.
Oke, J. B. 1974, ApJS, 27, 21.