Rev. Mexicana Astron. Astrof., 12, 269-272 (1986)

ON THE NATURE OF THE UNUSUAL NEBULA PL1547.3-5612

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RESUMEN. Con el fin de determinar la naturaleza de PL1547.3-5612, se investiga la consistencia entre la información sobre esta nebulosa, obtenida de las observaciones y las distintas hipótesis sobre su origen.

ABSTRACT. In an attempt to understand the nature of PL1547.3-5612, a comparison is made between the observed characteristics of this nebula and the several different hypotheses for its origin.

Key words:

I. INTRODUCTION

PL1547.3-5612 was identified by van den Bergh (1979) as a planetary nebula, because of its ring-like appearance of about 1.5' in diameter, in an $H\alpha$ plate taken by him at the prime focus of the 4 m telescope of CTIO. Milne *et al.* (1979) reported that no emission from PL1547.3-5612 was detected in a survey with the Fleurs Synthesis Telescope at 1415 MHz.

Long slit spectrophotometry of PL1547.3-5612 (Ruiz, 1983) showed an unusual spectra with very prominent [NII]$\lambda\lambda$6548,6584 lines, suggesting the presence of gas with an abnormally high N abundance. The value of the $H\alpha/H\beta$ ratio measured at positions C and D (see Ruiz, 1983), indicated a distance of about 4 kpc from the Sun. At such a distance the ring should have a diameter of 1.2 pc with a thickness of 0.2 pc. Considering a density of about 300 cm^{-3}, given by the [SII]$\lambda\lambda$6717,6731 lines, the mass contained in the ring should then be 4 $M_\odot$.

II. OBSERVATIONS

During 1983 and 1984 several spectrograms were obtained, centered on different positions in the nebula. The spectrophotometry was done using the 1.5 m and 4 m telescopes of CTIO equipped with a Cassegrain spectrograph and a SIT Vidicon detector. The spectra obtained covered the range between 3700 Å and 7000 Å with a 10 Å spectral resolution. The data reduction was performed using the CTIO La Serena Computer Center.

III. RESULTS

In order to get accurate fluxes of weak lines, like $H\beta$, the spectra obtained in 1983 and 1984 had long exposure times, of about 40 minutes at the 4 m and 2 hours at the 1.5 m telescopes.

The values of the $H\alpha/H\beta$ ratio obtained for different positions in the nebula are given in Table 1 and the positions are indicated in Figure 1.

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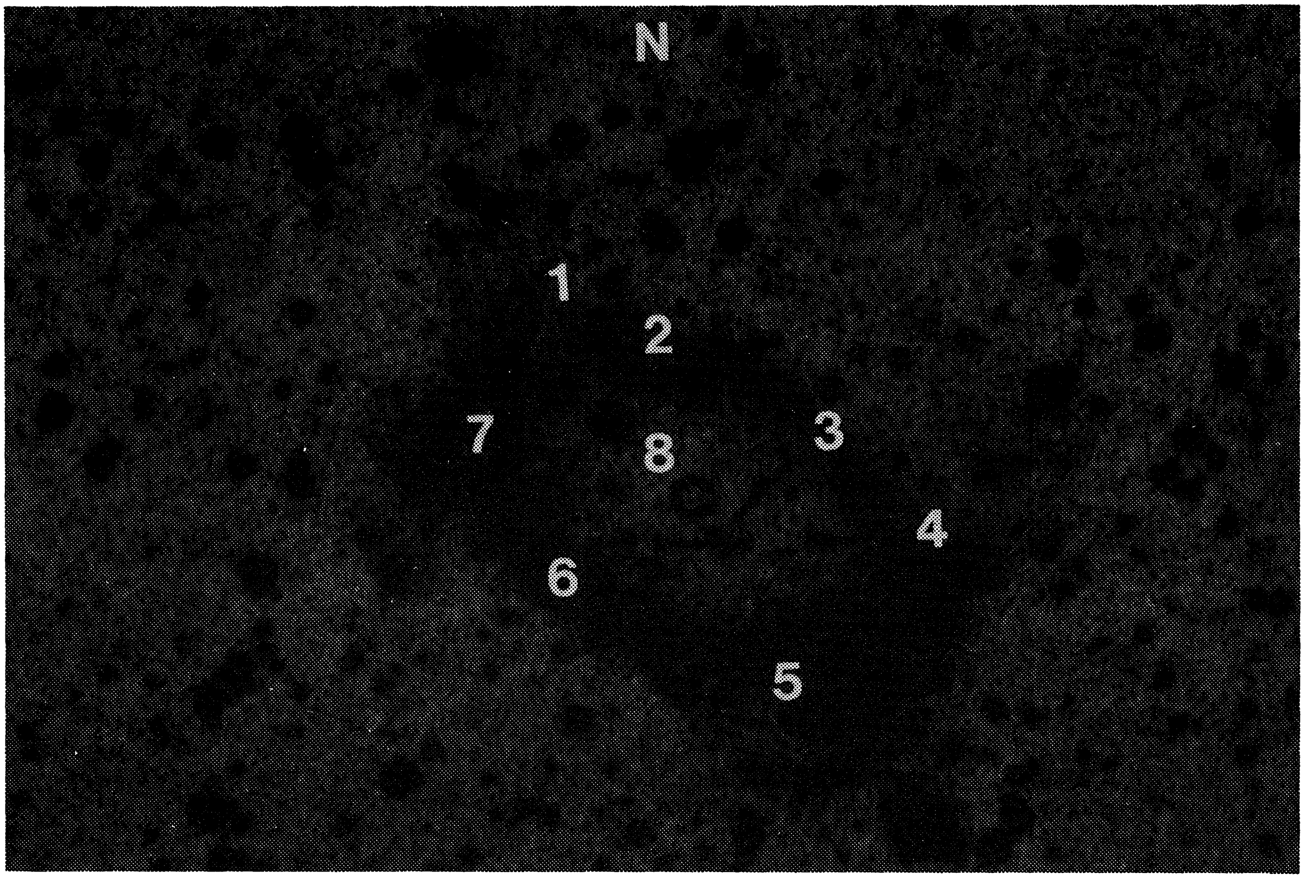

FIGURE 1. Positions where the spectra were taken are indicated over an Hα plate of PL1547.3-5612 taken by S. van den Bergh (1979).

TABLE 1

Position	Hα/Hβ	[NII]6584/Hα	[OIII]5007/Hβ
1	3.5	6.2	1.4
2	10.0	4.3	6.0
3	7.0	2.5	4.4
4	$\gtrsim$40 (:)	3.2	$\gtrsim$14 (:)
5	6.0	5.0	3.5
6	7.0	5.0	3.0
7	5.0	5.0	1.4
8	8.0	2.2	5.5

(:) Imprecise, Hβ at noise level.

From the observed values of the Hα/Hβ ratio one can see that the reddening changes from one position to the next without showing any apparent large scale distribution. The visual absorption goes from $A_V \gtrsim 0$ at position 1 to about $A_V \simeq 7$ mag at position 4. The near 0 absorption found at position 1 in the nebula means that the reddening found in other parts of the nebula is just local, related to PL1547.3-5612 itself. Thus, the distance of 4 kpc obtained by Ruiz (1983), taking the reddening observed at one position as interstellar and so as a distance indicator, is an overestimate.

The average absorption towards the galactic position of PL1547.3-5612 and within 2 kpc from the Sun is 1 mag (Lucke, 1978), thus, the value of $A_V \gtrsim 0$ mag found at position 1, and considering the errors involved in measuring the $H\alpha/H\beta$ ratio, place this object at a distance of 1 kpc or less.

The ratios [NII] λ6584Å/$H\alpha$ and [OIII] λ5007Å/$H\beta$ (see Figure 1 and Table 1), show a certain ionization structure, with the highest ionization occurring inside the ring and also in the northern half of it (positions 2, 3 and 4).

The densities obtained from the [SII] $\lambda\lambda$6717,6731 line ratios range from 100 cm^{-3} to 500 cm^{-3}. The ratio $H\alpha$/[SII] $\lambda\lambda$6717+6731 is about 2 suggesting the possibility that the emitting gas is being ionized by shocks (Sabbadin and Bianchini, 1977).

IV. DISCUSSION

In an attempt to try to understand the origin of this peculiar nebula, a discussion considering all available observations of PL1547.3-5612 and the different hypotheses for its origin is presented.

(a) PL1547.3-5612 as a SNR.

Favoring the SN origin for PL1547.3-5612 is the fact that the gas is overabundant in N, and also that the small $H\alpha$/[SII] line ratio suggests the presence of shocked gas. Unfortunately both characteristics have also been observed in a few low ionization planetary nebulae.

The absence of a visible photoionization source at the center (spectra taken of all the stars inside the ring showed them to be ordinary red stars) favors the SNR hypothesis, nonetheless, this can be easily explained if the central star is very hot with most of its energy emitted in the UV.

On top of the fact that there seems to be no strong evidence favoring the SNR origin, the small size of PL1547.3-5612 constitutes a very serious additional argument against it. At a distance of 1 kpc or less, the ring has a radius of 0.2 pc or less; such a small size implies a very young SNR whose ejecta should not be observable as a SNR yet.

(b) PL1547.3-5612 as a nova shell.

The large overabundance of N observed in PL1547.3-5612 is consistent with that found in nova shells, thought to be one of the main sources of N enrichment in galaxies (Williams, 1982). The strong and spotty reddening observed in PL1547.3-5612, suggesting the presence of dust, is also quite consistent with the nova shell hypothesis. Novae have been found to have large envelopes of dust surrounding them (Bode and Evans, 1983).

Taking, as typical values, for the mass of a nova shell $M_{NS} \sim 5 \times 10^{-5} M_{\odot}$, density $n_e \sim 300$ cm^{-3} (consistent with the value given by the [SII] lines) and a filling factor of 10% (Cohen and Rosenthal, 1983), one finds that the radius of the shell is $r_N = 0.026$ pc, and that locates PL1547.3-5612 at a distance of 130 pc, a value that is also compatible with the absence of reddening found at position 1 in the ring.

The only piece of evidence against the nova shell origin is the fact that one would expect to see the Main Sequence companion of the White Dwarf at the center of the ejecta. If we assume that the MS star has an absolute magnitude of $M \sim +5$, at a distance of 130 pc and with 4 mag of absorption, one should see a star of about $m \simeq 14.6$ mag, but the star at the center of the ring has $m \simeq 21$ mag.

(c) PL1547.3-5612 as a planetary nebula.

The same as in nova shells, there are a few planetary nebulae that have been found to have large N abundances and large dust envelopes, both consistent with the observations of PL1547.3-5612.

Considering a mass for the planetary nebula of Mp $\sim$ 0.2 $M_\odot$ (Osterbrock, 1974) and a density of $n_e \sim$ 300 cm^{-2} (given by the [SII] lines), one finds that the ring would have a radius of 0.19 pc at a distance of 950 pc for a filling factor of 100%, and for a filling factor of 50% the radius would be 0.24 pc at a distance of 1200 pc. The sizes are reasonable for a planetary nebula and the distances found compatible with observations of PL1547.3-5612.

As in the nova shell hypothesis, here, there is no strong evidence, considering the available observations of PL1547.3-5612, contrary to a planetary nebula origin for this object. The absence of a visible central star responsible for the ionization of the gas, can be explained if the star has a high surface temperature, emitting most of its energy at shorter wavelengths.

V. CONCLUSIONS

After the analysis, it seems that the presently available observations are equally consistent with PL1547.3-5612 being a nova shell or a planetary nebula. The spectroscopy of PL1547.3-5612 was of low resolution (10 Å), thus no velocity measurements were possible. A determination of the velocity of the gas will help to decide between hypotheses (b) and (c), because for nova shells one expects expansion velocities $v_{NS} \sim$ 500 km s^{-1}, while for planetaries it is less by an order of magnitude.

I am thankful to Dr. Miguel Roth for his hospitality at the Instituto de Astronomía (UNAM) in Ensenada, Mexico, while I was writing this manuscript. This research was partially supported by a grant from DIB (E.1706-8423), Universidad de Chile.

REFERENCES

Bode, M.F. and Evans, A. 1983, *Q.Jl.R.A.S.*, 24, 83.
Cohen, J.G. and Rosenthal, A.J. 1983, *Ap. J.*, 268, 689.
Lucke, P.B. 1978, *Astr. and Ap.*, 64, 367.
Milne, D.K., Goss, W.H., Haynes, R.F., Wellington, K.J., Caswell, J.L., and Skellern, D.J. 1979, *M.N.R.A.S.*, 188, 437.
Osterbrock, D.E. 1974, *Astrophysics of Gaseous Nebulae*, eds. G. Burbidge and M. Burbidge (W.H. Freeman and Co.).
Ruiz, M.T. 1983, *Ap. J. Lett.*, 268, L103.
Sabbadin, F. and Bianchini, A. 1977, *Astr. and Ap.*, 55, 177.
van den Bergh, S. 1979, *Ap. J.*, 227, 497.
Williams, R.E. 1982, *Ap. J. Lett.*, 261, L77.

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