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Sharpless 176: A Large, Nearby Planetary Nebula

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Summary. Spectroscopic and photometric investigations on S 176 indicate that this nebula is a Planetary Nebula with a radius of 0.40 pc at a distance of 140 pc. Its central star is a blue subdwarf with $M_v = +5.7$.

Key words: line intensities — planetary nebulae

Introduction

S 176 (Sharpless, 1959) is a faint arc of nebulosity whose dimensions are $12 \times 5'$ (Lynds, 1965).

Churchwell and Felli (1970) obtained for this nebula an upper flux limit at 2950 MHz of 0.5 f.u. and Felli and Perinotto (1974) a flux density limit of 0.2 f.u. at 1400 MHz.

Felli and Perinotto (1974) suggested that S 176 would be a reflection nebula illuminated by one or more stars with spectral type between G0 and M0.

The optical appearance of S 176 is rather similar to that of some old Supernova remnants contained in the Optical Atlas of Galactic Supernova remnants by van den Bergh et al. (1973).

We have studied this nebula to define its physical nature (H II region, reflection nebula, Supernova remnant or Planetary Nebula) and to obtain information on the physical conditions existing in the emitting gas.

Spectroscopic Observations

Six spectra of S 176 have been obtained with the image-tube spectrograph attached at the newtonian focus of the 122 cm reflector of the Observatory of Asiago. A description of the instrument is given by Benvenuti et al. (1975).

The spectrograph slit intersected the southern, brighter part of the nebula at a position angle of 90° and was kept fixed with respect to the nebula by guiding with offset stars.

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Table 1. Line intensity ratios observed in three positions of the filamentary arc of S 176

Position	H_α/[N II]	6717/6731	H_α/[S II]
1	0.39	1.26	1.61
2	0.32	1.30	1.70
3	0.35	1.28	1.65
Mean	0.35	1.28	1.65
Range	0.32–0.39	1.26–1.30	1.61–1.70

The spectra cover the range $\lambda\lambda$5700–7500 Å with a mean dispersion of 125 Å/mm. In this spectral range we have detected the lines H_α, λ6548 Å and λ6584 Å of [N II] and λ6717 Å and λ6731 Å of [S II]. Calibration plates have been obtained with the spot-sensitometer of the Observatory of Asiago and developed with the spectra. The reduction technique is described by D'Odorico (1974).

The slit of the microphotometer has been chosen to separate different emission features on the spectra. Because of the limited spectral range, corrections for spectral response of the instrument and atmospheric extinction have not been applied.

Line Intensity Ratios

Table 1 gives the H_α/[N II], 6717/6731 and H_α/[S II] intensity ratios in three positions of the filamentary arc of S 176.

[N II] and [S II] indicate the sum of the intensities of the lines of the doublet. The intensity of λ6548 Å of [N II], which in our spectra is sometimes blended with H_α, is assumed equal to 1/3 of the intensity of λ6584 Å.

Discussion

To obtain information on the physical nature of S 176 we have compared the line intensity ratios of Table 1 with those observed in Supernova remnants, in Planetary Nebulae and in H II regions.

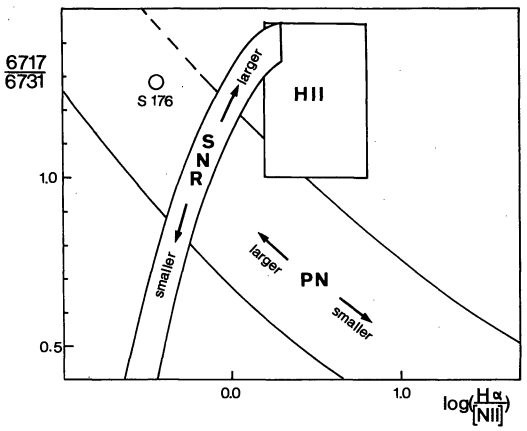

Fig. 1. Plot of the H_α/[N II] intensity ratio versus the ratio 6717/6731 of [S II] for Planetary Nebulae, H II regions, Supernova remnants and for S 176. References are given in the text.

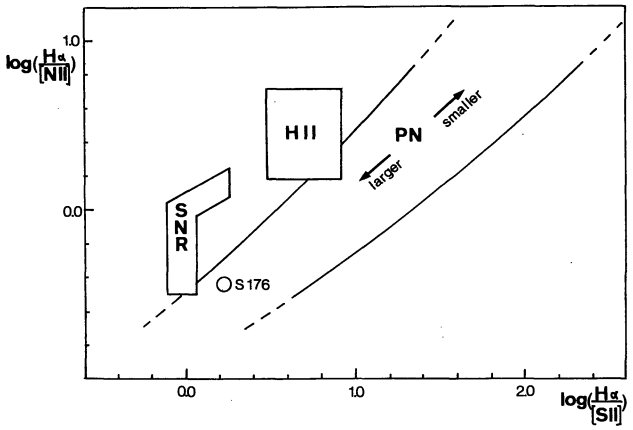

Fig. 2. Plot of the H_α/[N II] ratio versus the ratio H_α/[S II] for the same objects of Figure 1. References are given in the text

Figure 1 is a plot of the ratio H_α/[N II] versus the ratio 6717/6731 of [S II], which is a density indicator (Saraph and Seaton, 1970).

Sources of the line intensities are as follows: for Planetary Nebulae and H II regions we have used the mean value (corrected for reddening) contained in the Catalogue of relative emission line intensities observed in Planetary and Diffuse nebulae by Kaler (1976) and for galactic Supernova remnants the data by Daltabuit et al. (1976), Sabbadin and D'Odorico (1976) and Dopita (1976).

In Figure 2 we have plotted the H_α/[N II] ratio versus the ratio H_α/[S II] and in Figure 3 H_α/[S II] versus 6717/6731 for the same objects of Figure 1. A detailed analysis of the variation of the line intensities as a function of the evolutionary stage for Supernova remnants and Planetary Nebulae will be published in a future paper (Minello and Sabbadin, 1977).

The position of S 176 in Figures 1–3 indicates that this object is a large Planetary Nebula. The [S II] intensity ratio gives for the emitting gas an electron density of 500 ± 100 cm^{-3} (Saraph and Seaton, 1970), while the high intensity of [S II] and [N II] with respect to H_α indicates a rather low degree of excitation.

The Central Star of S 176

A blue star is visible inside S 176.

The UBV magnitudes of this star have been obtained with the iris photometer on three plates (centred at $\alpha = 00^h29^m$, $\delta = +58°30'$) with the 40/50 cm Schmidt telescope of the Observatory of Asiago (field diameter 6.3°) by comparison with the photoelectric sequence given by Hoag et al. (1961) for the open cluster NGC 129 ($\alpha_{1950} = 00^h29^m$, $\delta_{1950} = +59°57'$).

We obtain the following value:

$$V = 11.35 \pm 0.05$$
$$U - B = -0.55 \pm 0.05$$
$$B - V = 0.30 \pm 0.05.$$

One spectrum of the star has been obtained with the image-tube spectrograph attached at the cassegrain focus of the 183 cm reflector of the Asiago Observatory. The spectrum shows strong, broad Balmer lines in absorption and a weaker absorption line of He II at $\lambda 4686$ Å (probable spectral type: *sd* 0).

The preceding results seem to indicate that this star is the exciting star of S 176.

Distance and Dimensions of S 176

To obtain information on the linear dimensions and, then, on the distance of S 176 in Figure 4 we have plotted the [S II] electron density versus the radius for Planetary Nebulae. The electron density is derived from the mean 6717/6731 intensity ratio (Saraph and Seaton, 1970) as given by Kaler (1976), assuming for each nebula the electron temperature given by Cahn (1976). The radius is taken by Cahn (1976).

A general discussion of this graph will be given in a forthcoming paper (Minello and Sabbadin, 1977).

The [S II] electron density for S 176, when plotted in Figure 4, indicates a radius of 0.4 ± 0.05 pc and, then, a distance of 140 ± 30 pc (assuming an apparent radius of 10′).

The absolute visual magnitude of the central star results $M_v = +5.7 \pm 0.5$, a typical value for central stars of large Planetary Nebulae (Perek and Kohoutek, 1967).

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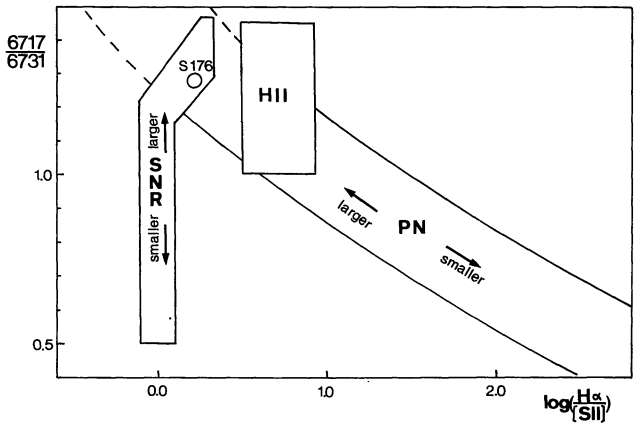

Fig. 3. Plot of the H_α/[S II] ratio versus the ratio 6717/6731 for the same objects of Figures 1 and 2. References are given in the text

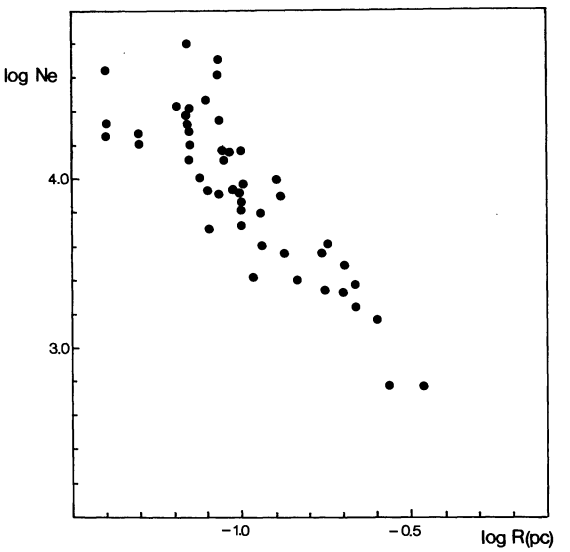

Fig. 4. Plot of the [S II] electron density versus the radius for Planetary Nebulae. References are given in the text

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