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ASTRONOMY AND ASTROPHYSICS

Detection of Six New Extended Planetary Nebulae by Means of Interference Filter Photography

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SUMMARY: Interference filter photographs in H_α+[NII] and 5007 Å ([OIII]) enabled us to find six new very faint planetary nebulae, tentatively identified on the POSS. In two nebulae central stars were found; one might be a variable.

KEY WORDS: interference filter photography - new planetary nebulae

INTRODUCTION

A sound knowledge of the number and nature of planetaries located within a few kpc of the sun is desirable: These objects hold a key position for estimating the mass return to the interstellar medium, its ionization, the chemical evolution of the galaxy and, more generally, provide insights into the late stages of stellar evolution (e. g. by comparisons of birth and death rates of white dwarfs). Whereas bright, nearby PN probably are long since nearly completely identified, the search for close PN of low surface brightness is seriously incomplete (see e. g. Pugathofer and Weinberger, 1980, and references therein).

Here we present six new PN of very low surface brightness. They were originally discovered on Palomar Sky Survey (POSS) prints, but could not unequivocally be classified there; four of them could even be mistaken for plate flaws on the prints.

OBSERVATIONS

Interference filter photographs of the objects were secured at the Cassegrain focus of the 182 cm reflector of the Asiago Observatory by use of an image tube (VARO 8605) in conjunction with a focal reducer. Exposure times ranged from 10 to 20 min for the (H_α+[NII]) filter (FWHM ∼40 Å) and amounted to 15 min for the [OIII]filter (FWHM ∼30 Å). These photographs were mainly taken for identification purposes and are not calibrated.

The brighter of the two central stars was found to be contained on 11 B plates obtained in the years 1972-1977 with the 67/90/210 cm Schmidt telescope of the Asiago Observatory for another program. Since this star is very faint on the plates and at best 4 out of 5 available sequence stars (close to the nearby globular cluster NGC 6535) were visible, 5 deeper B plates were taken with the 137/203/400 cm Schmidt camera of the K. Schwarzschild Observatory in Tautenburg. With 16 plates at hand we decided to look for possible brightness variations of the central star using the iris photometers of the observatories in Asiago and Innsbruck.

THE NEW NEBULA

In Fig. 1, identification charts of the new PN are given, reproduced from the red-sensitive POSS prints or the interference filter photographs, the only selection criterion being the better visibility.

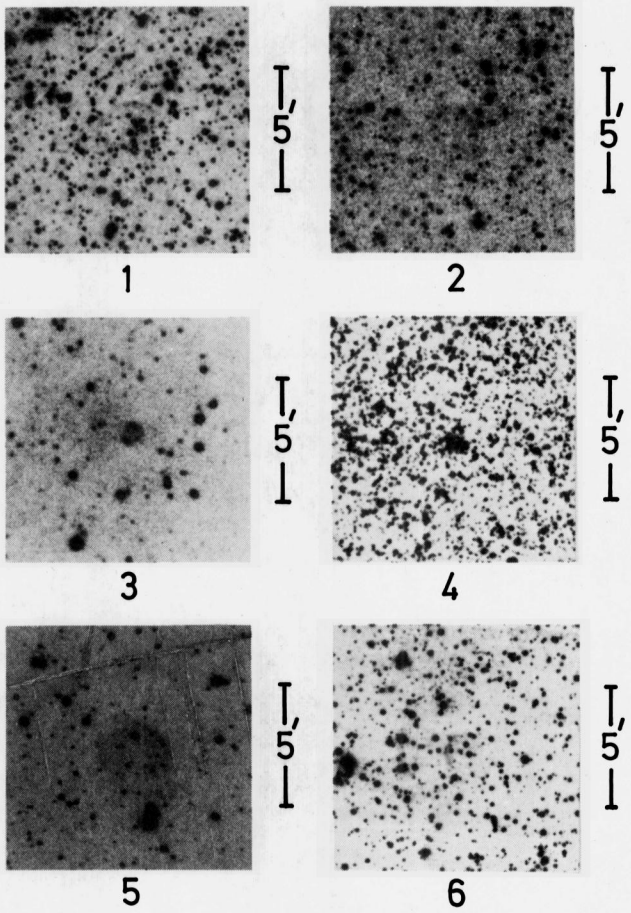

Fig. 1: Identification charts of the new planetaries. Nos. 1, 2, 4, and 6 are reproductions from the POSS (red-sensitive prints). Copyright by the National Geographic Society - Palomar Observatory Sky Survey. Reproduced by permission. Nos. 3 and 5 are reproductions of interference filter photographs at λ ∼5007 Å and at λ ∼6563 Å respectively, taken with the 182 cm telescope. North is at the top, east to the left.

Coordinates are tabulated in Table 1. They refer to the central stars, when identifiable (with an accuracy of ±2") or to the probable centres of the nebulae: in the (three) cases, where only half rings are observable (possibly caused by extinction), these are assumed to be complete rings, thus having definable centres.

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Table 1: Positions of the new planetary nebulae

NO	RA(1950) h m s	DEC(1950) ° ' "	ACC "	G-LONG °	G-LAT °
1	00 57 55.7	+54 47 30	±30	124.30	-07.79
2	06 13 01.2	+28 23 09	±20	183.81	+05.55
3	18 03 27.4	+00 22 16	± 2	028.04	+10.27
4	18 48 05.2	-01 06 48	±10	031.91	-00.31
5	19 59 29.1	+19 46 18	± 2	058.69	-05.58
6	23 10 53.4	+59 01 29	±20	110.66	-01.21

Surface brightnesses from the red and blue POSS prints (m_r^s, m_b^s) were estimated utilizing several measurements of Abell (1966) as a sequence and are reliable to about ±0.5 mag arcsec^{-2}. In cases of obviously incomplete nebular images, m_r^s data were estimated not only for the visible parts, but also tentatively for the invisible parts as being equal to the limiting surface brightness of 25.0 mag arcsec^{-2}; in doing so, we completed the visible parts in the most plausible manner, since in a next step, we computed the red integrated brightnesses (m_r^i) from the various sections of the respective nebulae and their projected areas. The latter conception (i. e. image completion) was also applied to the determination of angular volumes (v; in arcsec^3), where we assumed the ring structures to be shells, and a homogeneous ellipse to be an oblate ellipsoid. Furthermore, distances (r; uncorrected for interstellar extinction) were evaluated with Abell's (1966) distance formula. Abell's distances (which are based on the Shklovsky method), when applied to old PN, have received considerable support by the recent findings by Pottasch (1980). Pottasch states that likely only large (i. e. old) PN are optically thin and that their masses are probably $0.2 \lesssim M_\odot \lesssim 0.4$. Besides, choosing 0.4 $M_\odot$ instead of 0.2 $M_\odot$ (Abell and we chose 0.2 $M_\odot$) increases the distances by 30 percent only. Finally, linear diameters (D) of the PN were computed and can be found below.

All but one PN were photographed both in the (H_α+[NII]) and [OIII] lines, no. 2 only in (H_α+[NII]). No.1 is not visible on the [OIII] plate. However, these two objects are probably true planetaries too due to their appearance and remoteness from HII regions.

Individual Objects

Unless otherwise stated, the following remarks as to the shapes of the PN and their dimensions refer to the red sensitive POSS prints.

No 1: regular half ring with a mean thickness of 15". The diameter of the (completed) image is 155" ±10"; m_r^s (ring) = 24.1, the rest has an assumed m_r^s of 25.0, consequently m_r^i = 14.1; log v = 5.97 (spherical shell). We eventually derived r = 1500 pc, and D = 1.13 pc. The nebula is invisible on the blue print (i. e. $m_b^s \gtrsim 26.5$).

No 2: half ring with a mean thickness of 15" and m_r^s = 23.4 plus a rather homogeneous, hardly visible disk with m_r^s = 24.8. The overall diameter is 135"×135" (±10"); m_r^i = 14.0, log v = 5.83 (spherical shell); r = 1550 pc; D = 1.01 pc. Nothing visible on blue sensitive print.

No 3: almost rectangular homogeneous shape, 47" (±3") ×27" (±5"); m_r^s = 22.2, m_b^s = 25.7; m_r^i = 14.4. Because of its appearance on the [OIII] plate, we assumed a torus with an elliptical cross-section, seen edge-on, and having log v = 4.44. Consequently r = 3200 pc, D = 0.73 (outer diameter). A strikingly blue star is centrally located: its brightness is b = $16^m87 \pm 0^m11$ derived from the 5 plates taken at Tautenburg and b = $16^m80 \pm 0^m16$ from those 5 obtained in Asiago that contain at least 3 sequence stars. The central star seems to be variable as deduced from the above 10 plates; the remaining 6 plates support this suspicion. We intend to pursue this question by additional observations. Unfortunately, the only informations about the available sequence stars are m_{pg} data (Liller and Coutts, 1977) while we used plate and filter combinations yielding B magnitudes. Since the star has a steep (but unknown) energy distribution, a transformation into the m_{pg} or B system is futile.

No 4: small elliptical ring, 34" (±5") × 27" (±3"); m_r^s = 20.9 except a spot at the western end of the minor axis with m_r^s = 19.8. For the zone inside the ring we assume m_r^s = 25.0. Therefore, m_r^i = 14.0; log v = 4.05 (oblate elliptical shell); r = 3500 pc, D(mean) =0.53 pc. Since $m_b^s \gtrsim 26.5$, the nebula probably is heavily reddened and r is thus strongly overestimated.

No 5: elliptical, homogeneous disk, 150" (±10") × 155" (±15"); m_r^s = 24.2; m_r^i = 13.6; log v = 6.28 (oblate ellipsoid); r = 1200 pc; D(mean) = 0.89 pc; m_b^s = 26.4 (?). A blue, faint star is located at the centre of this PN. Its brightness, as estimated from the POSS is m_b = 17.4, m_r = 17.5 ($\pm 1^m$).

No 6: half ring with a mean thickness of 10". The diameter of the (completed) nebular image is 80" ±5"; m_r^s (ring) = 23.0; the rest has m_r^s = 25.0 (assumption). Consequently, m_r^i = 15.0; log v = 5.19 (spherical shell); r = 2550 pc; D = 0.99 pc. Nothing visible on the blue print.

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