

Hamburg Schmidt-Camera Survey of Faint Planetary Nebulae

Cygnus-Perseus Region

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The third part of the H_{α} Schmidt-camera survey of faint planetary nebulae contains the remaining area in the northern Milky Way $l\ 70^{\circ}$ – 146° , $b \pm 10^{\circ}$. 32 new planetary nebulae were classified — 6 of which are identical with the objects discovered very recently by Kazarjan and Parsamjan — and measured on the Palomar Sky Atlas. For the new nebulae the concentration towards the galactic equator was found higher than of those already known. In the Appendix three compact small $H\ II$ regions have been described.

Key words: planetary nebulae — galactic structure

Table 1. *List of plates*

No.	Plate	Field centre 1950		<i>n</i>
		α	δ	
1	GS 3597	20°32 ^m 5	+32°30'	1
2	4399	20 58.5	32 30	0
3	4346	19 45.0	37 30	0
4	4349	20 11.0	37 30	1
5	4352	20 37.0	37 30	2
6	4322	21 03.0	37 30	0
7	4663	21 29.0	37 30	1
8	4348	19 43.5	42 30	0
9	4359	20 11.5	42 30	3
10	4347	20 39.5	42 30	2
11	3773	21 07.5	42 30	1
12	4353	21 35.5	42 30	0
13	4392	22 03.5	42 30	0
14	4351	20 00.0	47 30	1
15	4405	20 30.2	47 30	2
16	4385	21 00.4	47 30	2
17	4360	21 30.6	47 30	2
18	3593	22 00.8	47 30	0
19	3585	22 31.0	47 30	0
20	4393	23 01.2	47 30	0
21	4723	2 36.0	47 30	0
22	4618	20 19.0	52 30	0
23	4391	20 52.7	52 30	2
24	4655	21 26.4	52 30	1
25	4619	22 00.1	52 30	0
26	3598	22 33.8	52 30	0
27	4394	23 07.5	52 30	1
28	4644	23 41.2	52 30	0
29	4706	0 14.9	52 30	0
30	4449	0 48.6	52 30	0
31	4721	1 22.3	52 30	0
32	4725	1 56.0	52 30	0
33	4722	2 29.7	52 30	0
34	4707	3 03.4	52 30	0

Table 1 (continued)

No.	Plate	Field centre 1950		<i>n</i>
		α	δ	
35	4689	20 41.7	57 30'	0
36	4680	21 19.6	57 30	0
37	4406	21 57.5	57 30	0
38	4386	22 35.4	57 30	3
39	3752	23 13.3	57 30	1
40	4690	23 51.2	57 30	0
41	4656	0 29.1	57 30	0
42	4657	1 07.0	57 30	0
43	4645	1 44.9	57 30	0
44	4693	2 22.8	57 30	0
45	4727	3 00.7	57 30	0
46	4228	3 38.6	57 30	1
47	3768	21 12.4	62 30	0
48	4651	21 55.5	62 30	0
49	4400	22 38.6	62 30	0
50	3761	23 21.7	62 30	2
51	4387	0 04.8	62 30	0
52	4691	0 47.9	62 30	0
53	4692	1 31.0	62 30	1
54	4658	2 14.1	62 30	2
55	4719	2 57.2	62 30	0
56	4249	3 40.3	62 30	1
57	4696	21 54.4	67 30	0
58	4724	22 43.8	67 30	1
59	4407	23 33.2	67 30	0
60	4401	0 22.6	67 30	0
61	4698	1 12.0	67 30	1
62	4699	2 01.4	67 30	2
63	4726	2 50.8	67 30	0
64	4694	3 40.2	67 30	0
65	4681	23 10.1	72 30	0
66	4697	0 14.3	72 30	0
67	4717	1 18.5	72 30	0
68	4718	2 22.7	+72 30	0

1. Introduction

Recently the first two parts of the H_{α} -survey of the Milky Way for faint planetary nebulae were published, the regions $l\ 32^{\circ}$ – 70° (1965 – Paper I) and $l\ 146^{\circ}$ – 214° (1969 – Paper II). This third part completes the survey of the northern Milky Way and covers the region $l\ 70^{\circ}$ – 146° , $b \pm 10^{\circ}$ between Cygnus and Perseus. Here again the Schmidt-camera 800/1200, $f = 2400$ mm of the Hamburg-Bergedorf Observatory with the 4° prism and the photographic plates Kodak 103a – E + RG 1 filter was used; the exposure time was 60 min and the widening of spectrum $10''$ in right ascension. In the period

October 1965–December 1970 68 fields of $5.5^{\circ} \times 5.5^{\circ}$ each, listed in Table 1 (plate number GS, field centre and number of new nebulae), were exposed. Plates Nos. 3585–3598 were taken in October 1965, Nos. 3752–3773 in September–October 1966, Nos. 4228–4249 in December 1968–February 1969, Nos. 4322–4449 in July–October 1969 and Nos. 4618–4727 in August–December 1970. The limiting magnitude was not equal for the different plates, but in average it was the same as during the first part of the survey, e.g. ~ 17.8 mag in Kron and Smith's red system.

Table 2. *Planetary nebulae*

Name	Design.	α_{1950}	δ_{1950}	p_{α}	p_{δ}	l	b	I	Plate
K 3–73	84+9°1	20 ^h 02 ^m 53	+49°10'6	1 ^o 74	+10°21	84°02	+9°51	2	14
3–74	78+5°1	20 07.02	+42 21.3	2.04	10.55	78.61	+5.22	2	9
3–75*	77+3°2	20 13.60	+40 25.5	2.12	11.03	77.68	+3.13	2	9
3–76	73–2°1	20 23.11	+33 25.0	2.36	11.72	73.01	–2.43	2	1
3–77*	78+0°1	20 27.50	+40 05.3	2.17	12.03	78.93	+0.76	2	5, 10
3–78	88+4°1	20 43.82	+50 11.7	1.86	13.14	88.71	+4.62	2	15, 16, 23
3–79	92+5°1	20 51.77	+53 34.3	1.75	13.65	92.12	+5.81	3	23
3–80	84–4°1	21 05.77	+40 45.8	2.28	14.52	84.07	–4.44	2	11
3–81	83–8°1	21 20.27	+37 54.4	2.41	15.37	83.94	–8.44	2	7
3–82	93–0°1	21 29.11	+49 46.9	2.11	15.85	93.36	–0.99	2	17
3–83	94–0°1	21 33.98	+50 40.8	2.10	16.11	94.54	–0.85	2	24
3–84	91–4°1	21 36.92	+45 46.9	2.27	16.26	91.65	–4.84	1	17
3–85	108+0°1	22 48.89	+59 14.4	2.39	19.09	108.17	+0.13	3	38
3–86	106–4°1	22 52.65	+54 40.0	2.53	19.18	106.63	–4.20	2	27
3–87	107–2°2	22 53.03	+56 26.5	2.49	19.19	107.44	–2.62	2	38, 39
3–88	112+3°1	23 10.18	+64 23.0	2.47	19.57	112.57	+3.80	2	50
3–89*	112–0°1	23 21.93	+60 41.0	2.68	19.77	112.54	–0.14	1	50
3–90	126+3°1	1 21.55	+65 23.0	4.09	18.79	126.38	+3.00	2	61
3–91	129+4°1	1 54.79	+66 19.5	4.54	17.58	129.55	+4.56	2	62
3–92	130–3°1	1 59.91	+64 43.2	4.49	17.36	130.48	+3.15	2	54
3–93	132+4°1	2 22.49	+65 34.4	4.79	16.29	132.47	+4.70	2	62
3–94	142+3°1	3 32.01	+59 53.8	4.91	+12.06	142.15	+3.49	2	46, 56

Table 3. *Possible planetary nebulae*

Name	Design.	α_{1950}	δ_{1950}	p_{α}	p_{δ}	l	b	I	Plate
K 4–51*	77+3°1	20 ^h 10 ^m 64	+40°36'4	2°11	+10°82	77°52	+3°70	1	9
4–52*	76+1°2	20 15.43	+38 40.9	2.18	11.17	76.43	+1.86	2	4
4–53	78–2°1	20 40.35	+37 29.7	2.29	12.91	78.38	–2.80	2	5
4–54	84+2°1	20 41.20	+45 45.7	2.03	12.96	84.96	+2.20	3	15
4–55	84+1°1	20 43.43	+44 28.3	2.08	13.11	84.20	+1.09	2	10
4–56	86+0°1	20 54.02	+46 21.7	2.06	13.80	86.84	+0.87	1	16
4–57	107–0°1	22 46.58	+58 13.2	2.39	19.02	107.45	–0.64	2	38
4–58*	111+6°1	22 47.27	+66 45.8	2.10	19.04	111.39	+6.94	2	58
4–59	127–1°1	1 27.24	+60 15.9	3.94	18.61	127.73	–1.98	3	53
4–60	132–0°1	2 04.48	+60 31.8	4.30	+17.16	132.16	–0.72	2	54

*) See the text.

2. New Planetary Nebulae

The selection of planetary nebulae from the list of all emission objects in the region was described in Paper I: the continuous spectrum near the emission H_α line was required to be either absent or very little. Besides new objects were examined on the direct Schmidt plates and especially in the Palomar Sky Atlas.

The list of 22 new planetary nebulae is given in Table 2, the list of 10 new possible planetary nebulae in Table 3. The numbering of nebulae follows up with Paper I and II, the abbreviations K 3- . . and K 4- . . (for possible planetary nebulae) were applied according to the Catalogue of Galactic Planetary Nebulae (CGPN - 1967). The "Design.", which is the "galactic number" of the respective nebula, corresponds also with the system of the Catalogue.

The spherical co-ordinates of the planetary nebulae were measured in the Palomar Sky Atlas using three reference stars chosen from the AGK 3 catalogue for each object. The accuracy of the measurements was lower than in Paper I and II, but sufficient for their identification and further study: the r.m.s. error of the α and δ is $\pm 0^m.02$ and better than $\pm 0.1'$, respectively.

The tables contain also the annual precession p_α , p_δ in the right ascension and declination, the galactic co-ordinates l , b , the intensity I of the H_α line on a relative scale (1 - strong, 2 - medium, 3 - faint) and the reference to the field (see Table 1) in which the respective nebula is located.

We believe that the classification of all nebulae in Tables 2 and 3 is guaranteed with a relatively high probability. There are of course two possible types of objects which could erroneously be taken as planetary nebulae: various emission-line stars, and small compact H II regions. The diffuse features of most objects of Tables 2 and 3 seen in the Palomar Atlas (see Table 4) indicate that their confusion with emission-line stars is impossible. Besides, all objects but one (K 3-80) show no observable continuous spectrum near the H_α line. Nevertheless, objective-prism spectra of five starlike nebulae are required for their final classification. On the other hand some nebulae (e.g. K 4-53, K 4-60) might possibly be found very small H II regions.

The planetary nebulae in Tables 2 and 3 marked by asterisks have very recently been discovered by Kazarjan and Parsamjan (1971) independently; Kazarjan and Parsamjan's No. 1 = K 4-51, No. 2 = K 3-75, No. 3 = K 4-52, No. 5 = K 3-77, No. 6 = K 4-58 and

No. 8 = K 3-89. The identity of those objects could be decided by just comparing identification charts, while co-ordinates given in both papers have shown relatively large discrepancies. Emission H_α line of Kazarjan and Parsamjan's No. 4 and No. 7 was not detected in our survey.

The possible planetary nebula K 4-51 (Kazarjan and Parsamjan's No. 1) is identical with MWC AS 389 (Merrill and Burwell, 1950).

3. Description of Individual Objects

Measurements of angular diameters, position angles of the major axis, and surface brightness, H (in magnitudes per circle $1'$), from the Palomar Sky Atlas are summarized in Table 4. Most nebulae are overexposed on the red prints, so that only upper limits of their angular diameters and surface brightnesses could be given. The surface brightnesses were estimated using de Vaucouleurs' (1959) measurements of surface magnitudes in M 33. The data in brackets refer to the external envelope (peripheral structure) of the nebula.

The determination of small diameters ($\leq 5''$) are influenced due to the seeing. In Table 4 the observed angular diameters, d_{obs} , were corrected: $d_{\text{cor}} = \sqrt{d_{\text{obs}}^2 - d_*^2}$, where d_* is the angular diameter of that star image the "surface brightness" of which was the same as the surface brightness of the respective nebula. The values d_* were found to be between $1.7''$ and $3.1''$.

The identification charts for all new objects as reproduced from the E-prints of the Palomar Sky Atlas are given.

It is necessary to point out that some of the objects being identified as planetary nebulae and therefore included in the Catalogue, are probably of different nature. In the investigated region there are:

Kr 1-1 ($121-2^\circ 1$) and Kr 1-2 ($88+6^\circ 1$), discovered by Krasnogorskaja (1962). Both objects show on the E-prints of the Palomar Sky Atlas a non-stellar nucleus surrounded by a not homogeneous nebulosity. The nuclei are neither stars nor emission nebulae because no H_α line in emission appears. Besides, the nebulosities are not typical for planetary nebulae. Therefore Kr 1-1 and 1-2 do very probably not belong to the class of planetary nebulae.¹⁾

¹⁾The classification of the further objects of Krasnogorskaja's list as planetary nebulae, Kr 2-1 ($149-1^\circ 1$) and Kr 2-2 ($114+10^\circ 1$) is very improbable, too. Their irregular nebulosities suggest most likely reflection nebulae.

Table 4. *Measurements on Palomar Sky Atlas*

Name	Red print (E)				Blue print (O)				Remark
	Dimensions		p.a.	<i>H</i>	Dimensions		p.a.	<i>H</i>	
	"	"	°		"	"	°		
K 3-73	< 18	< 16	90	≈ 11	17	15	90	12.8	
3-74	23	20	90	≈ 11.4	21	18	90	14.5	
3-75	< 10	< 8	90	≈ 11	3.5:			15.2	1,2
3-76	< 8.5			≈ 11	4.3			12.5	1
3-77	< 15			≈ 11	8.7	6.7	110	13.8	3
3-78	< 7			≈ 11	3.2			13.4	1
3-79	12.0			≈ 11.9	10.8			14.3	
3-80	< 10			≈ 11	5.8			12.5	
3-81	< 11			≈ 11	< 11.5			≈ 12	6
3-82	< 24			≈ 11	19			≈ 14.0	4
3-83	< 9			≈ 11	unmeasurable			≈ 16	
3-84	≈ 12	≈ 10	0	≈ 11	≈ 10	≈ 8.5	0	≈ 12	
3-85	< 6.5			≈ 11	4:			≈ 15.5	2
3-86	10.4			≈ 11.4	9.3			13.9	
3-87	≈ 7			≈ 11	3.5			13.8	1
3-88	< 9			≈ 11	5.1			14.8	1
3-89	< 11			≈ 11	3.8			13.5	1
3-90	< 12.5			≈ 11	9.0			13.3	
3-91	14.6	6.9	35	≈ 11.4	5.8			15.2	2,5
	(15)	(21)	(115)	(13.1)					
3-92	12.3			≈ 11	7.3			13.6	
3-93	10.7	8.8	165	≈ 11.9	1.7			14.8	1
3-94	< 12.5			≈ 11	7.1			13.0	
K 4-51	< 10			≈ 11	5.6			12.5	
4-52	< 7			≈ 11	< 6.2			≈ 12	6
4-53	22	19		≈ 11.5	16	11		14.3	7
4-54	< 6.5			≈ 11	4:			15.2	1,2
4-55	33	22	0	≈ 11.5	18	9	25	14.9	8
	(35)	(74)	(100)	(14.1)					
4-56	< 8			≈ 11	< 4.0			≈ 12	6
4-57	< 5.0			≈ 11	—			—	6
4-58	< 10	< 7:	0	≈ 11	6.8	4:	0	≈ 15.4	2
4-59	< 4.5			≈ 11	< 3.8			≈ 12	6
4-60	13.4	8.3	55	≈ 11.6	invisible			≈ 16	9

1) The angular diameter of the nebula measured on the blue print represents the observed value corrected due to the seeing. See the text.

2) The nebula is very faint on the blue print, the measurement of its angular dimensions is uncertain.

3) On the blue print oval disc with a suggestion of faint symmetrical ansae; a faint trace of the central star.

4) On the blue print ring nebula with the mean thickness of the ring of about 2"8 (corrected); the central star has $m_B \sim 19^m.5$.

5) On the red print rectangular nebula with the peripheral structure.

6) Stellar in both colours.

7) Irregular nebula.

8) On the red print two faint symmetrical loops.

9) Two small prominences.

K 3-50 (70+1°), discovered in the first part of our survey, however, shows the emission spectrum, typical for a low-excitation planetary nebula (Rubin and Turner, 1971), but many papers based on radio measurements locate it in compact H II regions.

M 1-77 (89-2°) and M 2-54 (104-6°), discovered by Minkowski (1946, 1947), are other peculiar cases. Both objects show H $_{\alpha}$ line in emission, but a relatively strong continuous spectrum, and on objective prism plates in the blue region no other emission lines (for M 1-77) or very weak Balmer lines only

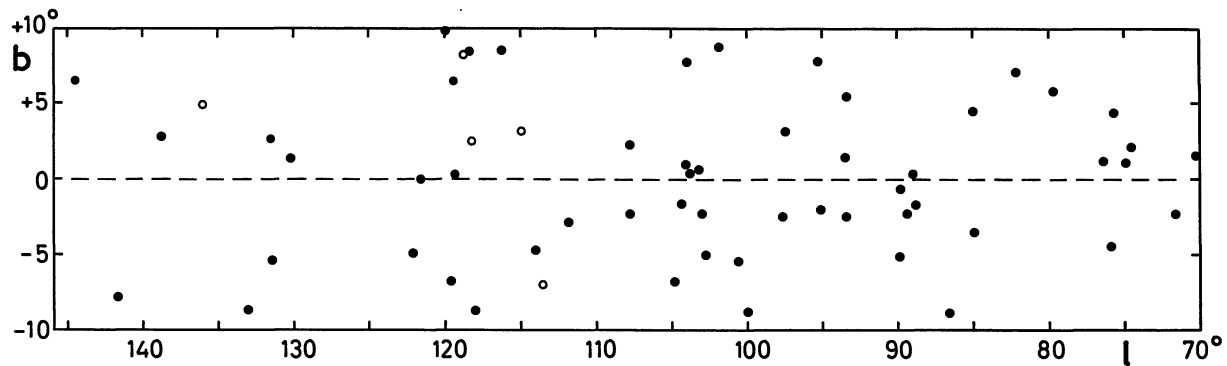


Fig. 1. Distribution of the known planetary nebulae in galactic co-ordinates in the region $l\ 70^\circ-146^\circ$, $b\ \pm 10^\circ$. The empty circles stand for nebulae not found in the H_α -survey plates (their surface brightness is too low).

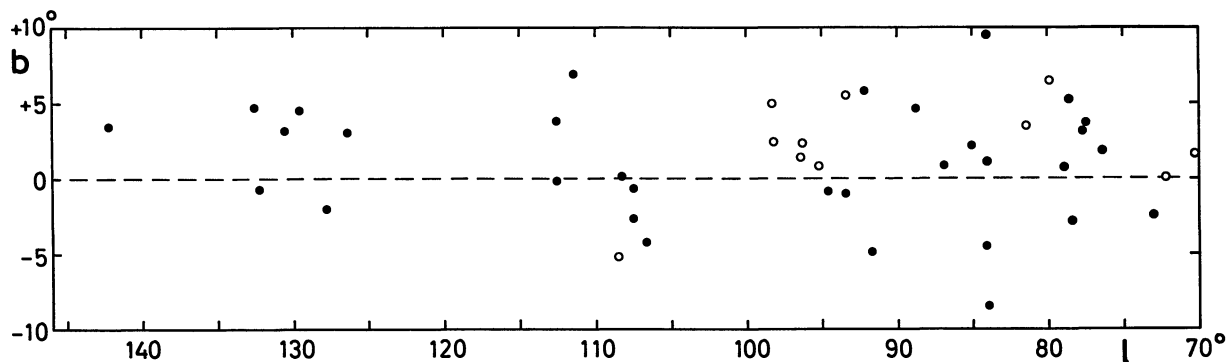


Fig. 2. Distribution of the new planetary nebulae in galactic co-ordinates in the same region. The empty circles stand for nebulae discovered in the supplementary programme of the first part of the H_α -survey (Paper I)

(for M 2-54) appear. The aforesaid supports the opinion that these objects could belong to emission-line stars.

M 2-56 ($118+8^\circ 1$) has H_α in emission, if any, near the plate limit of our survey. We can believe, that this object was brighter in the year of its discovery (Minkowski, 1947) than at the present time and should therefore rather be added to novae or variable stars than to planetary nebulae. Further studies of the objects mentioned above are necessary.

4. Distribution over the Sphere

An investigated area between $l\ 70^\circ$ and 146° and $b\ \pm 10^\circ$ contains according to the CGPN 73 known planetary nebulae. However, 11 of them were discovered in the supplementary programme to the first part of our H_α -survey (Paper I). Without the inclusion of objects Kr 1-1 ($121-2^\circ 1$) and Kr 1-2 ($88+6^\circ 1$) in our statistics, the number of planetaries

known in this area up to the Hamburg-Bergedorf H_α -survey and shown in Fig. 1 amount to 60.

Figure 2 contains new planetary nebulae of Tables 2 and 3 (full circles) and of the first part of our H_α -survey (empty circles), altogether 43 objects.

Comparing both figures we can see that:

a) The distribution of the known planetary nebulae is in the first approximation symmetrical towards the galactic equator, while the new nebulae show a large excess in the northern hemisphere, especially in the longitudes $l\ 70^\circ-100^\circ$.

b) The concentration of the nebulae towards the galactic equator is higher for the new objects than for the already known. If $n_{0,5}$ and $n_{5,10}$ are the numbers of nebulae in the latitude band $b < 5^\circ$ and $5^\circ \leq b < 10^\circ$, ratio $n_{0,5}/n_{5,10}$ is only 1.5 for the known nebulae, whereas it is 4.4 for the new nebulae. The most logical explanation of this effect, which was also stated in Papers I and II, is that the average distance of the new nebulae might be larger (about

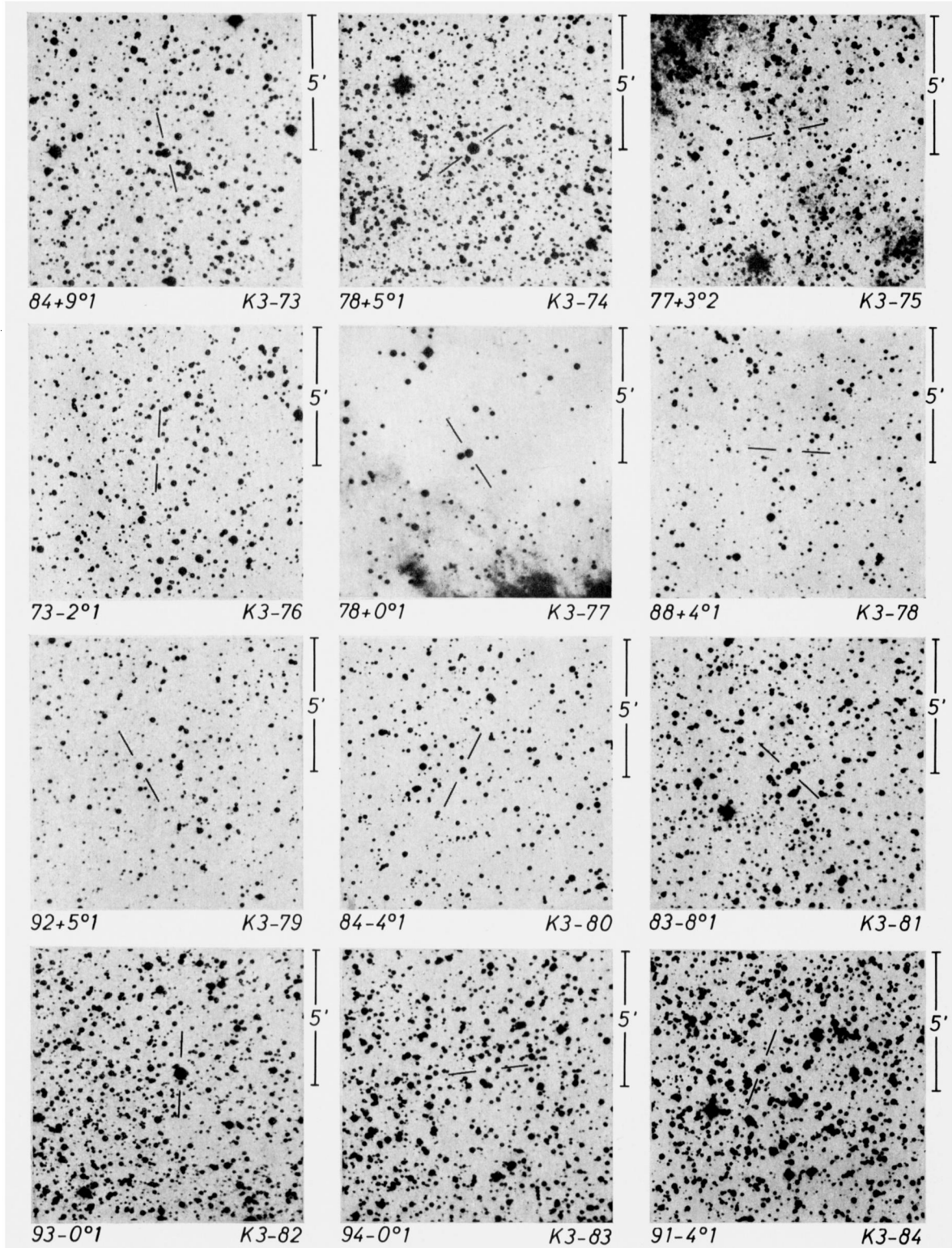


Fig. 3

Figs. 3–5. Identification charts for planetary nebulae and H II regions reproduced from the National Geographic Society – Palomar Observatory Sky Survey (E-prints). North is at the top

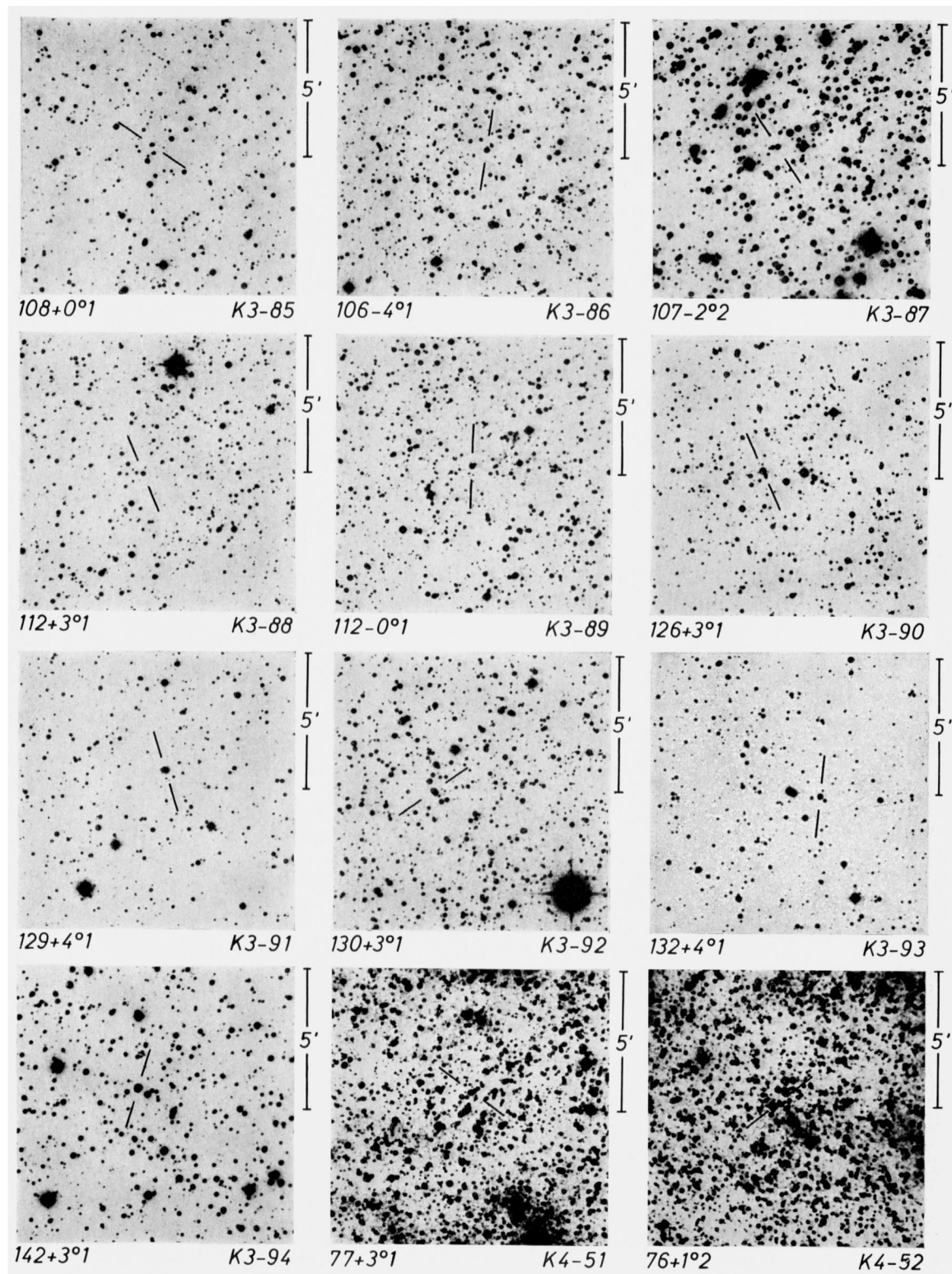


Fig. 4

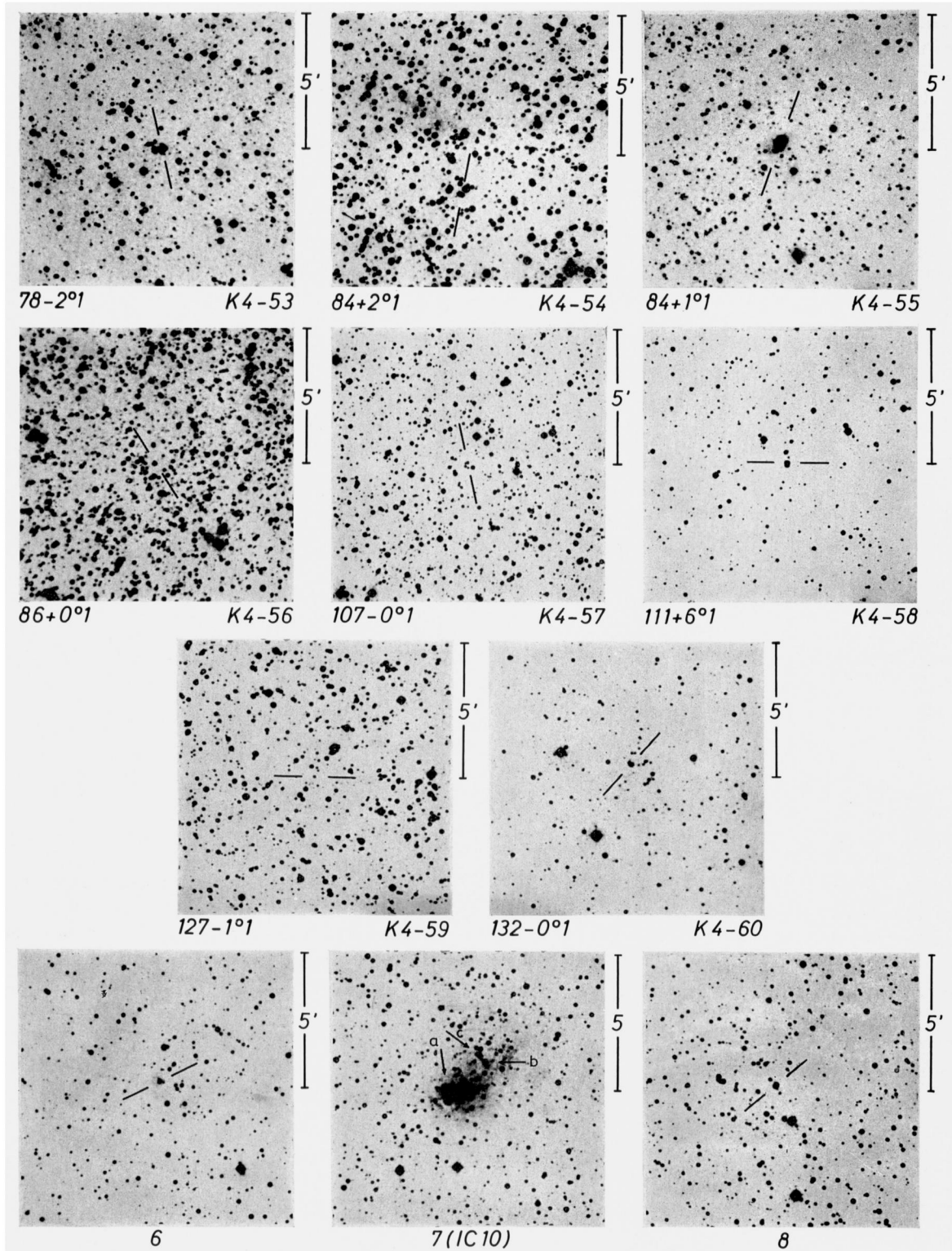


Fig. 5

twice) with respect to the known objects. This conclusion is supported not only by the lower brightness of the new nebulae compared with that of the nebulae discovered earlier as well as in the previous H_{α} survey, but also by their smaller average angular diameters. Besides, no substantial differences of the absorption were found in the regions occupied by new and already known objects.

c) The distribution of the new nebulae in the galactic longitudes is not homogeneous contrary to the distribution of the known objects. There do exist regions with no planetary nebulae occurring: l 100° – 105° , 115° – 125° , 135° – 140° .

5. Conclusion

The third and last part of the H_{α} -survey of the northern Milky Way with the Schmidt camera of the Hamburg-Bergedorf Observatory covers an area between Cygnus and Perseus, l 70° – 146° , $b \pm 10^{\circ}$. In this region 73 planetary nebulae were known, 11 of which were discovered in the supplementary programme of the first part of our survey (Paper I). Further 32 faint objects with H_{α} line in emission and without observable red continuous spectrum have been classified as planetary or possible planetary nebulae in this part of the survey. 6 of these are identical with nebulae very recently discovered by Kazarjan and Parsamjan (1971) in the Byurakan Observatory. The spherical co-ordinates of the nebulae were measured in the Palomar Sky Atlas with an accuracy of $\Delta_{\alpha} = \pm 0^m.02$, $\Delta_{\delta} \leq \pm 0.1'$. Most of the nebulae in the Palomar Atlas show diffuse features and diameters between $2''$ and $33''$, 5 objects appear starlike. Similar to the first two parts of our survey the concentrations towards the galactic plane was found higher for the system of new nebulae than for the already known objects. Probably the double average distance of the new nebulae compared with the known nebulae can be assumed. An excess of the new objects in the northern hemisphere and their non-uniform distribution in the galactic longitudes

have been noticed. The extension of the Hamburg-Bergedorf H_{α} -survey in the southern Milky Way is planned for the next years.

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Appendix

Three small compact H II regions were identified in the Cygnus-Perseus region except planetary nebulae and stars with the H_{α} line in emission. The spherical and galactic co-ordinates of these objects are given in Table 5; the numbering of nebulae follows up with Paper II. The identification charts are published together with the charts of the planetary nebulae.

Table 5. Compact H II regions

No.	α_{1950}	δ_{1950}	p_{α}	p_{δ}	l	b	Plate
6	21 ^h 20 ^m 24	+51°58'0	1.98	+15'37	93.86	+1.56	24
7a	0 17.74	+59 01.0	3.25	19.98	118.98	-3.34	41
b	0 17.57	+59 02.0					41
c	0 17.59	+59 02.3					41
8	1 21.75	+63 41.3	4.02	+18.78	126.62	+1.32	53

Description and measurements of the individual H II regions in the Palomar Sky Atlas:

No. 6 (+54°, 21^h32^m). On the red print: bright nebulous nucleus 7'' in the diameter, $H \cong 11^m5$ (in mag per circle 1'), lying excentrically in a faint non-homogeneous 28'' nebula ($H \cong 14^m$). On the blue print: very faint nebulous nucleus 2'' in the diameter, $H \cong 15^m$.

No. 7 (+60°, 0^h00^m) identical with IC 10. A large irregular nebulosity contains three bright nebulous nuclei (*a*, *b*, *c*) showing H_α in emission. On the red print: a) dark overexposed nebula, 16'' in dia.;

b) bright oval disc, 12'' × 9'', $H \cong 11^m5$;

c) bright oval nebula, 16'' × 10'', $H \cong 11^m5$, appearing as a composition of two nuclei.

On the blue print: a) bright almost circular 12'' nebula, $H \cong 13^m5$;

b) oval disc, 6'' × 5'', $H \cong 12^m5$;

c) two nebulous nuclei 3.5 each, $H \cong 13^m6$.

No. 8 (+66°, 0^h52^m). On the red print: oval overexposed nebula 15'' × 10'' in the dimensions, with two faint symmetrical prominences. On the blue print: faint small nebula, 6'' in dia., $H \cong 14^m8$.