New DSH Planetary Nebulae and Candidates from Optical and Infrared Surveys

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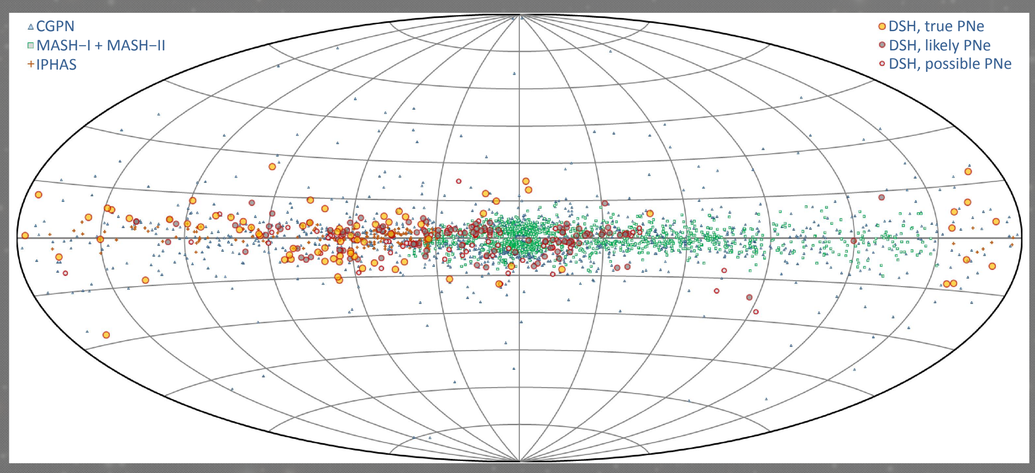
Introduction

During the last decade, more than one hundred previously unknown true, probable and possible planetary nebulae (PNe) have been published by amateur astronomers within the framework of the Deep Sky Hunters (DSH) project. The majority of candidates were found by scanning the Digitized Sky Survey (DSS) and other publicly available digital resources (SDSS, GALEX, WISE), or by inspecting [S II]/Hα/[O III] narrowband images of the Milky Way taken with modern CCD imagers [1–5].

Current status

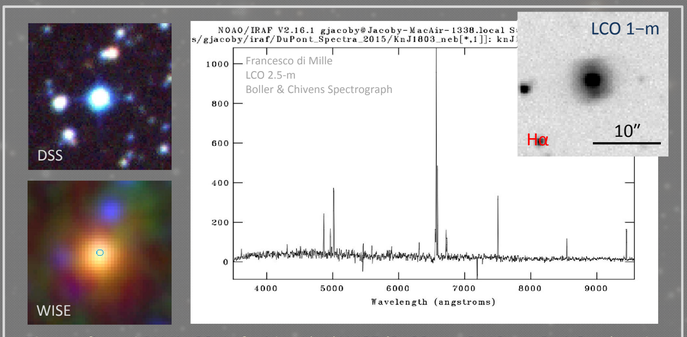


Distribution of the True, Likely and Possible PNe of the DSH sample in an Aitoff–Hammer projection of the Galactic Plane. All objects presented in the plot either have been published previously [1-4] or are listed of the present contribution. Objects listed in the CGPN [8] and in the MASH–I [9], MASH–II [10] and IPHAS [11] catalogues are shown for comparison. Gaps in the DSH candidate distribution correspond to unsurveyed Milky Way regions.

Candidate status	Published [1-4]	This contribution	Total
True PNe (1)	73	6	79
Hα + [O III] emitters (2)	24	27	51
Hα emitters (3)	6	108	114
Awaiting Confirmation (4)	-	21	148
Non–PNe (5)	16	-	89
Total	119	**162**	481

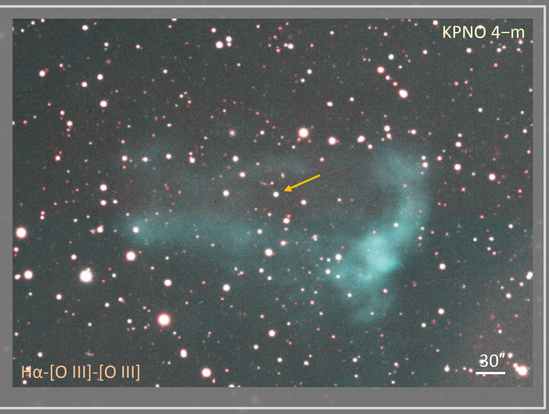
Summary of the status of all DSH PN candidates discovered thus far. The individual rows summarize: (1) Spectroscopically confirmed (=True) PNe; (2) Likely and Possible PNe validated as Hα and [O III] emitters from image data; (3) Likely and Possible PNe validated as Hα emitters but lacking [O III] imagery; (4) Possible PNe lacking confirmatory Hα + [O III] imagery and spectroscopy; (5) confirmed non-PNe .

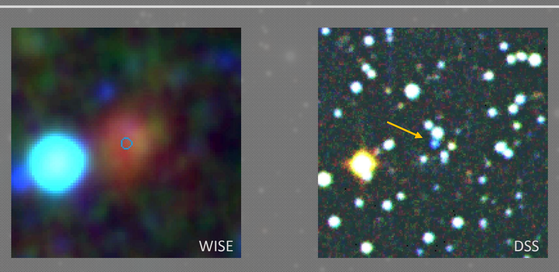
Examples



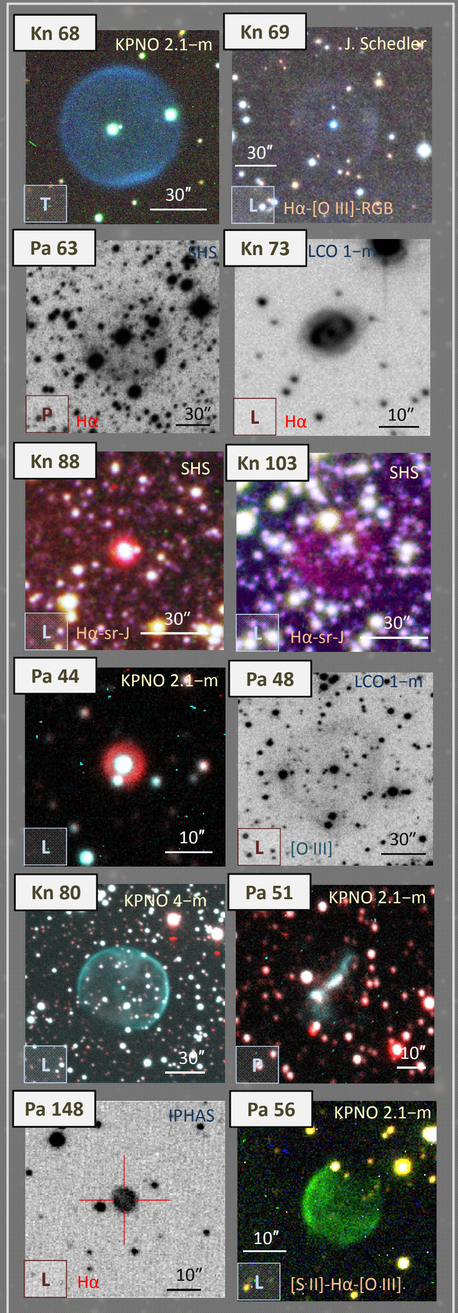
The confirmed PN Kn 99. Left side: 1'x1' WISE (R: 22um; G: 12um; B: 4.6um) and DSS (R: UKST-N; G: UKST-F; B: UKST-J) images. Right side: Broadband spectrum and Hα close-up image.

Alv 5, an old PN or possible mimic. A CSPN candidate is marked by an arrow.





Pa 143, a Possible PN requiring confirmatory narrowband imagery and spectroscopy. Left: 2' x 2' WISE multi–colour image (R: 22um; G: 12um; B: 4.6um). Right: False–colour image generated from DSS–II images taken in the blue, red and near–IR. The arrow points toward a possible CSPN centered in the WISE source.



Narrowband images of various True (T), Likely (L) and Possible (P) PNe presented in this contribution. Unless otherwise noted, R = Hα, G,B = [O III].

New PN candidates

The table below presents 162 previously unknown objects that were discovered during the past two years and are expected to be true, likely or possible PNe based on their morphologies, their spectral properties, and their characteristics at optical and infrared wavelengths. The majority of candidates are located within the boundaries of the SHS [6] and IPHAS [7] Hα surveys and were discovered by combining mid–IR data from the Wide–Field Infrared Survey Explorer (WISE) with optical data from the IPHAS, SHS and DSS surveys, and with UV data from the GALEX mission. Object sizes found at optical wavelengths range from stellar to several arcmin. Not listed are another ~130 objects that we consider to be PN candidates based only on their mid-IR characteristics. We plan to obtain Hα + [O III] images of these candidates, and confirmatory spectroscopy of the possible and likely PNe, during the next years.

Object ID	RA [2000.0]	DE [2000.0]	l [°]	b [°]	Diam. ["]	Type	Notes
Pa 58	00 06 01.4	+60 52 01	117.43	-01.51	117 x 103	P	(2),(1)
Pa 59	01 14 39.0	+61 19 44	125.71	-01.41	24 x 20	L	
Pa 153	05 09 07.5	+53 10 28	155.99	+07.74	167 x 165	P	(3)
Kn 81	06 20 11.4	-58 39 04	267.62	-26.89	48 x 41	P	(3)
Kn 69	07 09 41.5	-62 14 24	272.94	-21.74	67 x 61	L	
Kn 68	**07 22 03.1**	**+27 13 33**	**191.09**	**+18.30**	**64 x 62**	**T**	
Pa 60	07 40 10.5	-24 29 52	240.10	-01.03	97 x 54	L	
Kn 71	08 16 42.5	-72 59 36	286.08	-19.96	71 x 71	P	(3)
Kn 70	09 27 07.9	-67 51 26	285.47	-12.22	102 x 102	P	(4)
Pa 42	**13 54 49.6**	**-52 04 48**	**312.73**	**+09.58**	**33 x 30**	**T**	
Pa 61	14 34 34.1	-56 18 33	316.92	+03.73	22 x 14	P	
Pa 62	14 37 49.0	-57 47 22	316.74	+02.20	4 x 4	P	
Pa 63	14 54 09.3	-56 48 17	319.16	+02.14	82 x 82	P	(2)
Pa 64	15 03 28.0	-57 34 43	319.91	+00.87	8 x 4	P	
Pa 65	15 06 32.8	-56 26 07	320.84	+01.66	6 x 3	L	
Pa 66	15 12 11.7	-55 44 57	321.86	+01.85	3 x 3	L	
Pa 67	15 14 07.2	-56 05 06	321.92	+01.43	54 x 49	L	
Pa 68	15 26 35.4	-55 19 13	323.81	+01.13	21 x 21	L	
Pa 69	15 38 38.3	-50 20 59	328.17	+04.14	6 x 4	L	
Pa 70	15 44 39.2	-52 26 46	327.65	+01.90	6 x 6	L	
Pa 71	15 55 45.5	-50 45 41	330.05	+02.13	4 x 4	L	
Pa 72	16 01 10.1	-51 05 24	330.49	+01.33	11 x 8	L	
Kn 72	16 13 12.8	-67 04 59	320.77	-11.50	10 x 10	L	
KnPa 2	**16 18 37.1**	**-17 24 15**	**357.41**	**+22.88**	**8 x 7**	**T**	
Kn 82	16 20 16.2	-48 15 22	334.68	+01.30	stellar	L	
Kn 83	16 22 17.6	-47 13 45	335.65	+01.79	6 x 5	P	
Kn 84	16 22 44.3	-47 12 10	335.72	+01.75	stellar	L	
Kn 86	16 25 55.8	-43 57 55	338.42	+03.62	stellar	L	
Pa 43	**16 28 24.6**	**-20 23 08**	**356.58**	**+19.18**	**49 x 44**	**T**	
Kn 85	16 29 37.7	-47 16 17	336.48	+00.87	8 x 4	L	
Kn 96	16 34 30.3	-39 19 01	342.93	+05.64	9 x 9	L	
Kn 73	16 39 31.6	-64 48 10	324.34	-11.91	18 x 13	L	
Kn 95	16 40 06.4	-40 19 46	342.89	+04.17	11 x 11	L	
Kn 88	16 40 21.2	-45 01 12	339.40	+01.02	4 x 3	L	
Kn 100	16 49 01.6	-38 27 43	345.43	+04.07	9 x 7	L	
Kn 87	16 51 10.4	-47 46 42	338.52	-02.18	stellar	L	
DGPK 2	16 52 59.6	-40 30 46	344.34	+02.18	4 x 4	L	
DGPK 1	16 53 31.3	-40 28 44	344.43	+02.12	6 x 6	L	
Pa 73	16 56 01.3	-37 32 54	347.02	+03.59	10 x 10	P	
Kn 90	16 56 51.1	-45 07 05	341.20	-01.27	stellar	L	
Kn 92	16 59 03.2	-44 42 48	341.76	-01.32	5 x 5	L	
Kn 89	17 02 39.5	-46 08 01	341.03	-02.69	10 x 10	L	(5)
Kn 94	17 03 56.9	-44 50 12	342.19	-02.08	10 x 10	L	
Kn 97	17 05 55.6	-43 53 30	343.16	-01.79	stellar	P	
Kn 98	17 06 19.6	-43 15 33	343.71	-01.47	4 x 4	L	

Object ID	RA [2000.0]	DE [2000.0]	l [°]	b [°]	Diam. ["]	Type	Notes
Kn 91	17 10 09.7	-46 16 57	341.69	-03.82	6 x 5	P	
Kn 104	17 12 34.4	-40 30 59	346.61	-00.77	7 x 7	P	
Alv 5	17 12 41.7	+01 55 33	022.91	+22.76	340 x 200	P	(4)
Kn 102	17 14 25.0	-41 44 34	345.81	-01.77	stellar	L	
Kn 108	17 16 32.7	-39 27 14	347.91	-00.76	10 x 10	L	
Kn 93	17 19 25.9	-47 15 48	341.81	-05.68	12 x 8	L	
Pa 74	17 26 56.7	-37 38 59	350.55	-01.40	6 x 5	L	
Pa 76	17 27 22.1	-37 27 15	350.76	-01.36	5 x 3	L	
Pa 75	17 28 22.0	-37 42 51	350.66	-01.67	8 x 6	P	
Kn 107	17 30 02.9	-41 18 51	347.83	-03.94	17 x 15	P	
Kn 106	17 30 15.9	-41 21 37	347.81	-04.00	16 x 15	P	
Kn 103	17 32 33.4	-43 29 41	346.25	-05.52	36 x 36	L	
Kn 109	17 32 40.3	-40 44 58	348.57	-04.04	5 x 5	L	
Pa 77	17 37 11.0	-38 03 19	351.32	-03.32	3 x 3	P	
Pa 78	17 40 59.3	-32 11 23	356.70	-00.86	10 x 6	L	
Kn 101	17 43 18.0	-45 28 41	345.56	-08.18	11 x 11	L	
Pa 79	17 47 10.9	-16 39 54	010.70	+06.03	13 x 13	L	(6)
Pa 80	17 50 42.4	-20 59 34	007.40	+03.11	20 x 15	L	
Pa 81	17 51 54.4	-12 58 16	014.49	+06.91	15 x 14	P	
Pa 82	17 53 57.3	-22 03 46	006.86	+01.91	stellar	P	
Kn 110	17 54 17.3	-40 37 02	350.82	-07.48	30 x 24	L	
Pa 83	17 57 52.1	-18 14 54	010.62	+03.03	18 x 15	L	
Pa 44	17 58 16.1	-12 47 57	015.42	+05.65	9 x 9	L	
Pa 84	17 58 20.2	-16 12 23	012.45	+03.95	7 x 6	L	
Pa 85	18 00 52.2	-19 13 46	010.12	+01.93	3 x 3	P	
Pa 45	18 01 03.7	-18 42 19	010.60	+02.15	4 x 3	L	
Pa 86	18 01 25.2	-16 52 30	012.24	+02.98	21 x 19	P	
Kn 99	**18 03 01.9**	**-48 29 40**	**344.53**	**-12.59**	**4 x 4**	**T**	
Pa 87	18 03 29.6	-12 25 05	016.38	+04.72	15 x 15	P	
Pa 88	18 04 35.3	-15 42 10	013.63	+02.89	stellar	L	
Pa 89	18 04 53.1	-13 49 30	015.31	+03.74	9 x 9	L	
Pa 90	18 05 49.8	-19 18 40	010.63	+00.87	4 x 4	P	
Pa 91	18 06 37.0	-12 06 15	017.02	+04.21	6 x 6	L	
Pa 92	18 11 22.4	-27 43 12	003.88	-04.30	stellar	P	
Pa 93	18 12 03.6	-30 31 02	001.48	-05.76	41 x 33	L	
Pa 94	18 12 39.4	-13 34 50	016.44	+02.21	4 x 3	L	
Pa 95	18 12 50.1	-14 49 15	015.37	+01.58	5 x 5	L	
Kn 74	18 14 10.9	-39 55 23	353.26	-10.49	16 x 14	L	
Pa 96	18 14 22.5	-14 37 37	015.72	+01.34	11 x 11	P	
Pa 97	18 14 32.7	-23 52 46	007.60	-03.10	stellar	P	
Pa 98	18 15 06.8	-19 59 31	011.09	-01.36	11 x 10	P	
Pa 99	18 15 22.9	-14 56 43	015.55	+00.98	18 x 15	P	
Pa 46	18 19 11.3	-34 20 18	358.77	-08.87	17 x 15	P	
Pa 100	18 19 45.1	-10 57 13	019.57	+01.93	3 x 3	L	
Pa 47	18 20 22.3	-07 12 16	022.96	+03.56	43 x 39	L	

Object ID	RA [2000.0]	DE [2000.0]	l [°]	b [°]	Diam. ["]	Type	Notes
Kn 105	18 21 20.3	-46 33 42	347.69	-14.54	< 10	P	(3)
Pa 48	18 21 29.8	-39 08 18	354.61	-11.41	74 x 67	L	(7)
Pa 101	18 22 39.0	-09 40 22	021.04	+01.90	9 x 7	P	
Pa 102	18 23 02.2	-04 58 25	025.25	+04.01	6 x 4	P	
Pa 49	18 24 19.7	-05 59 50	024.49	+03.25	10 x 2	L	
Pa 103	18 26 06.2	-23 46 40	008.93	-05.39	stellar	L	
Pa 104	18 28 41.5	-04 57 36	025.91	+02.77	22 x 19	P	
Pa 105	18 30 32.5	-05 55 12	025.27	+01.92	8 x 6	P	
Pa 106	18 31 44.7	-05 12 33	026.04	+01.98	11 x 11	L	
Pa 107	18 32 05.3	-15 43 18	016.75	-02.94	31 x 19	P	
Pa 108	18 33 03.4	-02 08 43	028.92	+03.10	3 x 3	L	
Pa 109	18 33 51.4	-24 02 50	009.50	-07.09	stellar	P	
Pa 110	18 38 00.7	-12 41 07	020.12	-02.82	30 x 28	P	
Kn 77	18 38 01.7	-22 02 49	011.74	-07.06	stellar	L	
Pa 111	18 39 13.4	-12 25 41	020.48	-02.97	11 x 4	L	
Kn 78	18 39 54.0	-22 03 09	011.93	-07.45	20 x 17	P	
Pa 112	18 40 49.4	-02 59 51	029.05	+00.99	5 x 3	L	
Pa 113	18 42 02.3	+02 41 05	034.25	+03.31	6 x 5	P	
Pa 114	18 43 58.5	+01 52 48	033.75	+02.51	5 x 3	L	
Pa 115	18 44 39.3	-00 36 22	031.62	+01.23	11 x 10	P	
Pa 116	18 45 42.1	-14 47 47	019.08	-05.44	stellar	P	
Pa 117	18 47 12.1	+00 53 49	033.25	+01.35	4 x 4	L	
Pa 118	18 50 39.6	+04 16 41	036.65	+02.12	4 x 4	L	
Pa 119	18 53 11.9	-31 54 58	004.08	-14.29	< 10	P	(3),(8),(9)
Pa 120	18 53 43.5	-14 19 58	020.36	-06.97	23 x 21	P	
Pa 121	18 54 04.6	-09 01 48	025.17	-04.68	stellar	P	
Kn 79	18 57 46.4	-23 49 39	012.09	-11.92	5 x 5	L	
Kn 80	18 59 52.2	-20 34 48	015.31	-11.00	68 x 62	L	
Pa 122	19 04 24.5	+01 42 24	035.93	-02.10	10 x 8	L	
Pa 50	19 07 31.4	+01 18 22	035.93	-02.98	18 x 18	L	
Pa 123	19 07 50.0	+16 32 21	049.50	+03.94	15 x 12	P	
Pa 124	19 08 23.6	+02 33 01	037.13	-02.60	18 x 18	L	
Pa 51	19 08 52.3	+03 13 08	037.78	-02.40	32 x 25	P	
Pa 125	19 08 52.3	+12 02 41	045.62	+01.66	5 x 4	L	
Pa 52	19 09 34.9	+03 10 04	037.82	-02.58	8 x 8	L	
Pa 126	19 10 22.7	+04 35 13	039.17	-02.10	11 x 9	P	
Pa 127	19 10 51.0	+11 29 50	045.36	+00.98	stellar	L	
Pa 128	19 11 12.0	+11 47 26	045.66	+01.04	6 x 6	L	
LDûPa 1	19 11 56.2	+15 25 25	048.96	+02.56	6 x 4	L	
Pa 129	19 12 42.9	+05 45 46	040.48	-02.08	6 x 6	P	
Kn 75	19 16 52.3	-31 07 17	006.83	-18.67	stellar	P	(8)
Kn 76	**19 17 14.4**	**-30 28 12**	**007.51**	**-18.51**	**0.9 x 0.9**	**T**	**(8)**
Pa 130	19 19 38.1	+06 13 06	041.69	-03.39	29 x 24	P	
Pa 131	19 22 06.0	+11 32 41	046.68	-01.43	10 x 10	P	
Pa 132	19 23 11.5	+12 28 38	047.63	-01.23	5 x 4	P	

Object ID	RA [2000.0]	DE [2000.0]	l [°]	b [°]	Diam. ["]	Type	Notes
Pa 133	19 34 24.6	+22 33 51	057.77	+01.24	2 x 2	L	
Pa 134	19 36 15.3	+26 57 34	061.82	+03.01	18 x 18	L	
Pa 38	19 36 55.6	+08 54 07	046.10	-05.90	90 x 90	P	(4)
Pa 53	19 41 48.7	+27 52 02	063.21	+02.38	12 x 9	L	
Pa 135	19 43 12.5	+30 18 32	065.49	+03.32	45 x 45	P	
Pa 136	19 45 43.8	+27 14 50	063.12	+01.32	stellar	L	
Pa 137	19 49 54.1	+31 53 59	067.59	+02.88	23 x 23	L	
Pa 54	19 50 24.4	+11 02 39	049.61	-07.75	19 x 17	L	
Pa 138	19 50 32.9	+27 21 10	063.74	+00.45	39 x 39	P	
Pa 139	19 56 35.1	+27 41 52	064.72	-00.51	6 x 6	L	
Pa 140	19 56 38.5	+30 04 14	066.76	+00.70	14 x 12	P	
Pa 141	19 57 45.4	+30 45 56	067.48	+00.86	6 x 6	P	
Pa 142	20 02 52.3	+31 11 23	068.41	+00.15	4 x 3	P	
Pa 143	20 04 14.9	+35 51 52	072.53	+02.39	43 x 33	P	
Pa 144	20 06 31.8	+09 26 21	050.22	-11.99	27 x 23	P	(3)
Pa 145	20 12 15.7	+25 22 14	064.62	-04.73	7 x 7	L	
Pa 146	20 29 09.4	+15 37 00	058.58	-13.39	113 x 88	P	(3)
Pa 147	20 29 23.6	+45 17 56	083.03	+03.70	80 x 55	P	
Pa 40	20 33 37.2	+30 16 21	071.37	-05.83	95 x 95	P	(4)
Pa 55	20 39 22.0	+48 13 57	086.41	+04.08	23 x 23	L	
Pa 148	20 41 28.3	+47 06 33	085.73	+03.11	7 x 6	L	
Pa 149	20 51 46.9	+50 46 40	089.66	+04.08	10 x 8	L	
Pa 150	20 57 10.1	+48 34 29	088.53	+01.99	9 x 4	P	
Pa 56	21 11 20.9	+49 37 42	090.87	+00.97	20 x 17	L	
Pa 151	21 19 40.1	+46 46 34	089.77	-02.00	5 x 5	P	
Pa 57	21 51 01.6	+59 35 26	101.86	+04.32	16 x 16	L	
Pa 152	22 14 58.0	+66 32 59	108.23	+08.25	40 x 29	P	(3)

Yellow: spectroscopically confirmed PNe

Type:
T ... true PN
L ... Likely PN
P ... Possible PN

Notes:
(1) Surrounding WDS 00060+6052
(2) Strømgen sphere?
(3) Confirmatory imagery required
(4) Mimic?
(5) Listed as PN in [12]
(6) Superimposed on open cluster Messier 6
(7) Appears to surround V406 CrA
(8) member of Sgr dSph?
(9) = WISE 40; WR?

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