Planetary Nebulae: An Eye to the Future
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New faint planetary nebulae from the DSS and SDSS

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Abstract. Having surveyed ≈ 10% of the sky, we have identified more than 130 PN candidates by surveying multicolour Digitized Sky Survey (DSS), Sloan Digitized Sky Survey (SDSS), and combined [O III], Hα and [S II] images. In a first imaging and spectroscopy campaign, 51 objects were identified as true and probable PNe. This work presents an additional 17 probable or possible PNe identified since that study. The majority of these candidates are situated at Galactic latitudes $|b| > 5°$, with the exception of seven objects located closer to the Galactic plane. Using the techniques described here that do not require any new survey data, we anticipate that many more PNe are waiting to be found, perhaps as many as 90.

Keywords. planetary nebulae: general, surveys

Recent Hα surveys such as the AAO/UKST SuperCOSMOS Hα survey of the Southern Galactic plane (SHS: Parker *et al.* 2005) and the INT Photometric Hα Survey of the Northern Milky Way (IPHAS: Drew *et al.* 2005) have been used to almost double the number of known Galactic planetary nebulae (PNe) (e.g. the Macquarie/AAO/Strasbourg Hα survey (MASH), Parker *et al.* 2006). However, both surveys cover only Milky Way regions close to the Galactic plane (SHS: $|b| \leqslant 10°$; IPHAS: $|b| \leqslant 5°$). Thus, it is likely that the current census of PNe is similarly incomplete beyond these limits.

The lack of high-resolution Hα or [O III] imagery in areas outside the SHS and IPHAS survey regions requires the use of other methods in order to identify new PNe. Possibilities are the visual inspection of multicolour Digitized Sky Survey (DSS) and Sloan Digitized Sky Survey (SDSS) images, and the survey for narrowband emitters on combined [O III], Hα and [S II] images. Both techniques have been used in the search for unknown PNe by members of the Deep Sky Hunters (DSH) team.

Applying these survey methods to fields mostly complementary to those covered by SHS and IPHAS has led so far to the discovery of more than 130 PN candidates in a sky region of $\approx 4000°^2$. In a first observing campaign, 76 candidates were imaged with the

Table 1. New PN candidates

Name	Other ID	R.A. J2000	Dec. J2000	l (°)	b (°)	Size ($''$)	Status	Notes
Kn 58		02:12:27.9	+47:27:10	136.85	−13.22	75 × 52	prob.	
Kn 60		07:00:06.7	+12:14:40	202.95	+07.45	5 × 5	prob.	
Kn 41		17:11:10.1	−13:57:34	008.35	+14.83	32 × 32	PN	
Kn 42		17:38:44.7	−12:57:20	012.87	+09.69	11 × 10	prob.	
CGMW 4-2085		18:38:07.9	−31:53:00	002.77	−11.36	17 × 15	PN	
Kn 59		18:41:41.9	+65:11:58	095.28	+25.45	4 × 4	prob.	[1]
Te 6	DSH J1909.9+1204	19:09:54.9	+12:04:52	045.77	+01.46	13 × 13	prob.	[2]
Kn 61	Soccer Ball Nebula	19:21:38.9	+38:18:57	070.52	+11.00	100 × 92	prob.	[3]
Kn 8	DSH J1922.6+2433	19:22:39.4	+24:33:02	058.24	+04.56	50 × 44	poss.	
Kn 56		19:37:43.8	−13:51:20	025.49	−16.41	40 × 25	prob.	
Kn 11	DSH J1941.3+2430	19:41:19.1	+24:30:53	060.25	+00.82	> 6 × 4	prob.	
Kn 7	DSH J1942.4+2145	19:42:26.1	+21:45:23	057.98	−00.77	23 × 15	prob.	[4]
Kn 9	DSH J1944.9+2245	19:44:59.1	+22:45:49	059.15	−00.78	> 330 × 270	poss.	[5]
Kn 14	DSH J2009.7+2407	20:09:42.2	+24:07:40	063.26	−04.91	16 × 13	prob.	
Kn 20	DSH J2021.4+3005	20:21:26.5	+30:05:39	069.70	−03.79	15 × 15	prob.	
Kn 48		20:38:09.2	+61:55:03	097.42	+12.37	42 × 36	prob.	
Ri 2	DSH J2050.0+3753	20:50:02.0	+37:53:17	079.50	−03.87	38 × 28	prob.	

Notes:
[1] Halo $228'' \times 174''$; [2] = IPHAS J190954.7+120455, Viironen *et al.* 2009; [3] located in Kepler target field; [4] = IPHASX J194226.2+214521, Viironen *et al.* 2009; [5] = WHI J1945+22, Whiting *et al.* 2007

WIYN 3.5m and the OHP 1.2m telescopes, and 60 of them were found to be probable or possible PNe, including ≈ 20% of spherical objects (Jacoby *et al.* 2010). Spectroscopic studies performed on 53 of these objects with the WIYN 3.5m and SAAO 1.9m telescopes confirmed 45 of them as PNe and identified one [WO] and at least two other emission line central stars (Frew *et al.* 2011, in prep.). Of the remaining seven targets without spectra, six have a high probability of being PNe based on their morphologies alone.

Since this first imaging and spectroscopy campaign, additional 17 objects from the candidate list have been identified as new possible and probable PNe. Table 1 lists the basic parameters of all objects. Objects described already in Kronberger *et al.* (2006) have their respective DSH IDs listed. Seven candidates were classified as probable or possible PNe according to their appearance on IPHAS Hα imagery. The remaining ten objects were imaged with the 2.1m and 4m KPNO telescopes and the WIYN 3.5m telescope. The latter instrument was also used to confirm the objects Kn 41 and CGMW 4-2085 spectroscopically as PNe. One of the new candidates, the Soccer Ball Nebula Kn 61, is located in the target field of the Kepler satellite, making it the sixth known PN in this sky region and the third one discovered in the framework of the DSH project after Pa 5 and PaTe 1 (Douchin *et al.* these proceedings).

From the number of objects identified so far, we anticipate that many more PNe can be identified with the described survey technique. By relating the number of new objects to the number of known PNe in the same region of sky, and extrapolating this to fields not yet surveyed, we estimate the number of additional detectable targets to 60 ± 30.

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