WISE properties of planetary nebulae from the DSH catalogue

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1. Introduction

2. WISE and planetary nebulae

3. WISE properties of DSH planetary nebulae

4. WISE as a tool of discovering new PNe

5. Special cases

6. Summary & Conclusions
The Deep Sky Hunters:
A group of (mostly) amateur astronomers hunting for unknown Deep Sky objects using various resources (DSS, SDSS, WISE, 2MASS, VIZIER, ....)

- **Foundation date:** June 2003
- **Number of members:** 370
- **Communication:** via yahoo newsgroup (http://groups.yahoo.com/neo/groups/deepskyhunters/info)
- **Emphasis:** Initially on open clusters and other stellar aggregates .....
1. Introduction

The Deep Sky Hunters: However, something new came up in Oct 2003!

Hi folks,

While poking around in Cygnus, I came across this image of a tiny nebula and its identity is a mystery to me. It was found on a blue DSS plate, which the link below reproduces an image 7' x 7' in size. J2000 coordinates are 19 47 03 +29 30 25. Kent Wallace has kindly checked and agrees that this position is pretty close.

Looks like it could be a planetary nebula, around 10 to 15 seconds of arc in diameter.


Regards,
Dana

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October 2003

Images of selected Milky Way regions has led to physical conditions for the formation of the solar system. This work is supported by the Austrian Science Fund (FWF). We thank the anonymous referee for comments that improved the paper. It is a pleasure to acknowledge the support of the UKIRT telescope and the wisdom of the UKIDSS collaboration. The UKIDSS project is supported by funding from the STFC and PPARC in the UK, the NSFC in China, the MoST and the AS in China, and the KASI and ASPRO in South Korea. The Large Binocular Telescope is a joint project of the University of Arizona and the Italian National Institute of Astrophysics. The Digitized Sky Survey Project was managed by the Space Telescope Science Institute under a grant from the National Aeronautics and Space Administration.

PA 1

10''

WIYN 3.5-

Digitized Sky Survey

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APN VI, 2013/11/04 – 08, Playa del Carmen, Mexico
1. Introduction

The DSH PN candidate validation queue

1. Look out for PN-like objects
   - publicly available Sky Surveys (mostly DSS)
   - amateur [S II]-H$_\alpha$-[O III] imagery

2. Check Databases

3. Contact Astronomers

4. Get narrowband images
   - WIYN 3.5-m
   - KPNO 2.1-m
   - KPNO 4-m
   - SPM 0.84-m
   - OHP 1.2-m

5. Validate candidates spectroscopically
   - WIYN 3.5-m
   - SAAO 1.9-m
   - SPM 2.1-m
   - OHP 1.2-m

M. Kronberger et al., WISE properties of PNe from the DSH catalogue
1. Introduction

Distribution of DSH PNe and candidates in the sky

3 B. Miszalski et al., MNRAS 384, 525 (2008)
4 L. Sabin, this contribution

5 G. Jacoby et al., PASA 27, 156 (2010)
6 M. Kronberger et al., IAUS 283, 414 (2012)
7 D. Frew et al., in preparation
8 M. Kronberger et al., poster B03, this contribution
1. Introduction

The DSH PN survey: current census

Most candidates located in areas complementary to IPHAS and MASH

Overall detection efficiency $\approx 60\%$
2. WISE and planetary nebulae

The Wide-field Infrared Survey Explorer (WISE)

Technical data

- Mission period: 2010/01 – 2011/02 (12 + 22um: 2010/01 - 2010/08)
- Bands: 3.4 um, 4.6 um, 12 um, 22 um
- Angular resolution: 6.1“, 6.4“, 6.5“, 12.0“
- Sensitivities: < 0.08 mJy, 0.11 mJy, 1 mJy, 6 mJy → 100x more sensitive than Akari and IRAS at these wavelengths!

Statistics

- >99% of the sky observed at least 2x in all bands
- Source catalogue: 563 million objects

http://wise2.ipac.caltech.edu/docs/release/allsky/figures/4band_cryo-w1-ach_equ-rh_crop.jpg


http://irsa.ipac.caltech.edu/Missions/wise.html

E. J. Wright et al., AJ 140, 1868 (2010)

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APN VI, 2013/11/04 – 08, Playa del Carmen, Mexico
2. WISE and planetary nebulae

Where does the emission observed with WISE originate from?

Fig. 2.—ISO-SWS spectrum of the planetary nebula NGC 6445

P. A.M. van Hoof, AJ 532, 384 (2000)

NGC 6445, ISO-SWS

M. Kronberger et al., WISE properties of PNe from the DSH catalogue
Where does the emission observed with WISE originate from?

Fig. 2.—ISO-SWS [S]
2. WISE and planetary nebulae

**Dust rich**

- SiC
- MgS
- (A) Silicates
- PAHs
- 16um bump

**High-excitation**

- SiC
- MgS
- (A) Silicates
- PAHs
- 16um bump


- **W1+2**: some line emission + CSPN, little continuum
- **W3**: PAH + continuum, high-excitation lines
- **W4**: Continuum + some [O IV]

\[ \text{WISE Band 1} \quad \text{WISE Band 2} \quad \text{WISE Band 3} \quad \text{WISE Band 4} \]

- **PNe considerably brighter in W3 & W4 than in W1 & W2**
- **Dust-rich PNe usually brighter than high-excitation PNe**
3. DSH PNe: WISE properties

The WISE properties of medium-to-high Galactic latitude PNe were studied by a subsample of the DSH PN catalogue:

Sample constraints

- True and Likely PNe
- Location: outside of $|b| = 5^\circ$
- Discovery method: visual surveying of DSS and SDSS images

→ „quasi-homogeneous sample“

Sample properties

- Total number: 52 Objects
- All main morphological classes (A,B,E,I,R) represented
- Sizes: almost stellar to several arcminutes
- ≈ 25% spherical, uniform shells

Morphological classification in accordance with MASH catalogue (Q.A. Parker et al., MNRAS 373,79 (2006))
3. DSH PNe: WISE properties

Asymmetric PNe (A,B,I)

All fields 3‘×3’, except Kn 64 (20‘×20‘)

R = W4
G = W3
B = W2
3. DSH PNe: WISE properties

Elliptical PNe

All fields 3×3, except Kn 50 (5×5)

R = W4
G = W3
B = W2
3. DSH PNe: WISE properties

Round, non-spherical PNe

Kn 42

All fields 3‘×3‘, except Kn 24 (5‘×5‘)

R = W4
G = W3
B = W2
3. DSH PNe: WISE properties

Spherical PNe

All fields 3′×3′, except Kn 45 and Kn 63 (10′×10′)

R = W4
G = W3
B = W2
3. DSH PNe: WISE properties – summary of results

**Size distribution**

- Objects < 30" almost entirely visible in WISE
- Larger objects less likely to show up

**Morphologies**

- Most asymmetric, elliptical and non-spherical round PNe are detected in WISE imagery
- Most spherical PNe are invisible on WISE imagery

### Size distribution:

- 0-30 arcsec: 89%
- 30-60 arcsec: 63%
- > 60 arcsec: 53%

### Morphologies:

- A: 0%
- B, B?: 100%
- E: 81%
- I: 100%
- R: 14%

PNe with WISE detection
### 3. DSH PNe: WISE properties – comparison with MASH PNe

#### Comparison of DSH data with statistics for MASH PNe outside of $|b| = 5^\circ$

<table>
<thead>
<tr>
<th>Size</th>
<th># total</th>
<th>% of WISE detections</th>
<th>DSH sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30 arcsec</td>
<td>133</td>
<td>90 %</td>
<td>89 %</td>
</tr>
<tr>
<td>30-60 arcsec</td>
<td>40</td>
<td>60 %</td>
<td>63 %</td>
</tr>
<tr>
<td>&gt; 60 arcsec</td>
<td>42</td>
<td>38 %</td>
<td>53 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th># total</th>
<th>% of WISE detections</th>
<th>DSH sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>43 %</td>
<td>(0 %)</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>64 %</td>
<td>100 %</td>
</tr>
<tr>
<td>E</td>
<td>106</td>
<td>81 %</td>
<td>81 %</td>
</tr>
<tr>
<td>I</td>
<td>2</td>
<td>100 %</td>
<td>(100 %)</td>
</tr>
<tr>
<td>R, non-Sph</td>
<td>39</td>
<td>95 %</td>
<td>100 %</td>
</tr>
<tr>
<td>R, Sph</td>
<td>36</td>
<td>39 %</td>
<td>14 %</td>
</tr>
<tr>
<td>S</td>
<td>11</td>
<td>91 %</td>
<td>-</td>
</tr>
</tbody>
</table>

Brackets: only one object in sample

- Very similar size dependence between MASH and DSH sample
- Very good agreement for elliptical and non-spherical round PNe
- Spherical PNe significantly less likely to be detected in WISE imagery
[W2-W3, W3-W4] colour-colour diagram:

- Only objects with clear detections in W3 or W4
- Multiple detections possible (especially for objects > 30")
DSH PNe: WISE properties – comparison with MASH PNe

[W2-W3,W3-W4] colour-colour diagram:

- Only objects with clear detections in W3 or W4
- Multiple detections possible (especially for objects > 30")

→ No fundamental (photometric) differences between different PN types, but large scatter in the data!
4. WISE as a tool for discovering new PNe

4. PN discoveries and characteristics at non-optical wavelengths

Jacoby & Van de Steene (2004) undertook an on/off-band bulge survey at [SIII] 9532Å, discovering 94 candidate PN. Also large numbers of PN candidates have been selected via their IRAS colours but confirmatory success rates have been low (e.g. Suarez et al. 2006, Ramos-Larios et al. 2009) so this is an inefficient technique. Mid-IR space-telescope images from Spitzer and WISE now allow detection of very reddened PN which may be invisible optically (e.g. Cohen et al. 2005, Kwok et al. 2008; Phillips & Ramos-Larios 2008). Furthermore, Carey et al. (2009) and Mizuno et al. (2010) have noted 416 compact (<1 arcmin) ring, shell and disk-shaped sources in the Galactic plane in 24μm Spitzer MIPSGAL images. Our belief is that many of these will turn out to be strongly reddened, high-excitation PN with only a minority being circumstellar nebulae around massive stars (Wachter et al. 2010). Note that PN can be quite strong mid-IR emitting objects because of PAH emission, fine structure lines, H$_2$ lines (UWISH2 survey, Froebrich et al. 2011) and thermal dust emission within the nebulae and in circumnuclear disks.

Parker, Q. A. et al., IAUS 283, 9 (2012):

> Mid-IR data can be a powerful tool to discover new PNe!

Figure 2. Upper panel: RGB colour montage from SuperCOSMOS H$_\alpha$, broad-band red and B$_{1}$ image of 2×1 arcmin region covering two newly discovered Galactic PN (circled) selected purely on the basis of their GLIMPSE colours. Lower panel: 3×1 arcsecond spectral slices from WiFeS red arm data centred on the brighter newly discovered PN interleaved with sky regions with the nod & shuffle technique. Wavelength increases from left to right. Note the [NII] > H$_\alpha$ ratio from the PN emission lines clearly visible as compact knots in three consecutive image slices.
4. WISE as a tool for discovering new PNe

- WISE survey for new PN candidates started outside of the MASH and IPHAS survey areas
- Project mostly followed up by D. Patchick
- Strategy: Combining WISE with DSS imagery to look for poss. CSPN + nebulosity

Preliminary results

- ≈ 25 new possible and likely PNe detected
- Sizes: almost stellar objects to several arcmin
- Many rings and asymmetric PNe, spherical objects clearly underrepresented

See also poster B03!
5. Special cases

**Kn 59**

- High-Galactic latitude object (\( b = +25.45^\circ \))
- PN-like, Medium-excitation spectrum
- **Morphology:**
  - small, bright core 4“x4“
  - halo 228“x174“ with multipolar characteristics
5. Special cases

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**WISE-characteristics:**

No emission detected at 22um!
5. Special cases

Te 11

• PN spectrum but very peculiar morphology
• Strong ISM interaction, poss with Barnards’ Loop
• CS: fairly red, eclipsing binary
• PN or symbiotic star?

B. Miszalski et al., APN V, 328 (2011)

M. Kronberger et al., WISE properties of PNe from the DSH catalogue
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- PN or symbiotic star?

WISE-characteristics:

Again, no emission at 22μm

¿ PN ?
5. Special cases

Pa 19 & Pa 30

- Located within IPHAS survey area
- characteristics:
  - W4-bright
  - blue CS (DSS):
    - Pa 19: B ~ 17.2, B-R ≈ -0.2
    - Pa 30: B ~ 15.5, B-R ≈ -0.3
  → Low reddening
- No nebulosity on IPHAS imagery

KPNO 2.1-m Hα + [O III] images taken June - October 2013

→ faint shells dominated by [O III] emission

¿ PNe ?
5. Special cases

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KPNO 2.1-m Hα + [O III] images taken June - October 2013

⇒ faint shells dominated by [O III] emission
6. Summary and conclusions

• The WISE properties of a subsample of the DSH True and Probable PNe were studied.

• Results:
  • Larger PNe are less likely to have a WISE detection than smaller PNe
  • Elliptical, non-spherical round, and asymmetric PNe: Similar detection probabilities and photometric properties
  • Spherical shells are significantly less often detected than all other PN types
  • 25 new PN candidates detected in a directed survey of the Milky Way using WISE imagery, many of them without optical counterpart on DSS, IPHAS or MASH

WISE is an excellent all-sky tool to detect new PNe and to reveal possible mimics

Not all PNe detectable with optical methods will show up also in WISE!
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• the VizieR catalogue access tool and the SIMBAD database, operated at CDS, Strasbourg, France.

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