

Planetary Nebula Candidates Uncovered with the HASH Research Platform

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Abstract. A detailed examination of new high quality radio catalogues (e.g. Cornish) in combination with available mid-infrared (MIR) satellite imagery (e.g. Glimpse) has allowed us to find 70 new planetary nebula (PN) candidates based on existing knowledge of their typical colors and fluxes. To further examine the nature of these sources, multiple diagnostic tools have been applied to these candidates based on published data and on available imagery in the HASH (Hong Kong/ AAO/ Strasbourg H α planetary nebula) research platform. Some candidates have previously-missed optical counterparts allowing for spectroscopic follow-up. Indeed, the single object spectroscopically observed so far has turned out to be a bona fide PN.

Keywords. Planetary Nebulae, Cornish, Color-Color Plots

1. Introduction

Modern multi-wavelength imaging surveys can help identify planetary nebulae hidden at optical wavelengths due to extinction (Cohen *et al.* 2011). The Cornish catalogue, which is based on the 5 GHz radio continuum Cornish survey (Hoare *et al.* 2012; Purcell *et al.* 2013), covers the northern GLIMPSE region (Benjamin *et al.* 2003; Churchwell *et al.* 2009), providing us with a new tool for the detection of PN candidates.

2. Selection Method and Diagnostic Tools

After cross-correlating the Cornish (Hoare *et al.* 2012; Purcell *et al.* 2013), NVSS (Condon *et al.* 1998) and Glimpse (Benjamin *et al.* 2003; Churchwell *et al.* 2009) catalogues, we rejected objects with $S_{5\text{GHz}}$ fluxes, >110 mJy or a spectral index $\alpha < -0.5$ following Anderson *et al.* (2011). We also included in our sample objects with no NVSS counterpart. After visual inspection of multi-wavelength images using the HASH database (Parker *et al.* 2016, and these proceedings), we uncovered 70 PN candidates, 21 of which have an optical detection, including our first confirmed PN (see Fig. 1).

Diagnostic tools using both emission-line and continuum fluxes from multiple wavelengths can be used to separate PNe from H II regions and non-thermal emitters (Cohen & Green 2001; Frew & Parker 2010; Parker *et al.* 2012; Frew *et al.* 2014). Previously known PNe have a median value of $F_{8\mu\text{m}}/S_{843\text{MHz}} = 4.7 \pm 1.1$, while H II regions and non-thermal emitters present MIR/radio ratios of ≈ 25 and ≈ 0.06 respectively (Cohen *et al.* 2007; Cohen *et al.* 2011). Assuming that all of our PN candidates are optically thin, we can convert their $S_{5\text{GHz}}$ fluxes to $S_{843\text{MHz}}$ by using the equation $S_{5\text{GHz}}/S_{843\text{MHz}} = (5/0.843)^{-0.1}$ (Anderson *et al.* 2011). In Figure 2 we can see the MIR/radio flux ratios of our PNe candidates overplotted on an IRAC color-color plot. The black and blue boxes indicate the areas where most known PNe and H II regions are placed, based on published data (Cohen *et al.* 2011). Data for other objects are obtained from Kurtz *et al.* (1994), Giveon *et al.* (2005) and Parker *et al.* (2012, 2016).

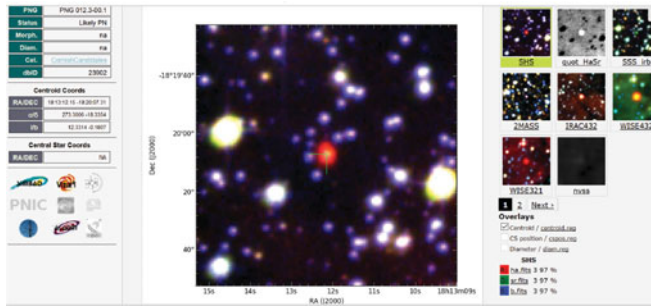


Figure 1. Example of a new PN discovered by this study, shown in HASH (Parker *et al.* 2016).

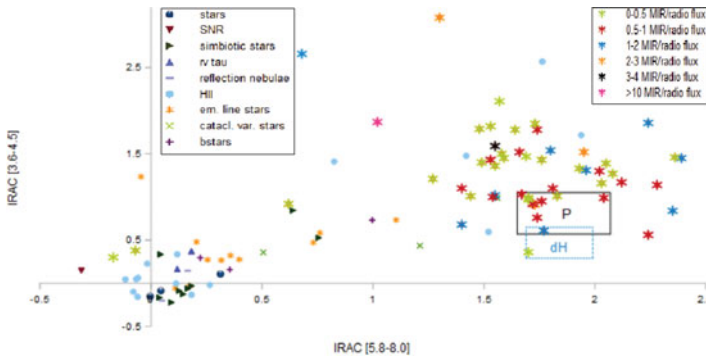


Figure 2. IRAC color-color plot of different object types.

3. Results

As shown in Fig. 2, most of our candidates are plotted on or around the box where most known PNe are located. Moreover, the MIR/radio flux ratios of most candidates agree well with previously known PNe, indicating there is a high probability of our candidates being true PNe. Follow-up studies are needed to confirm this hypothesis, especially for the 21 objects (30% of the total) that have optical counterparts allowing spectroscopic follow-up. At the time of writing, one of these has already been confirmed as a bona fide PN (Fig. 1). Future work should also investigate the sources with $S_{5\text{GHz}} > 110$ mJy.

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