

Identifying the Youngest Proto Planetary Nebulae

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Abstract. Detached shells can be identified from their NIR & MIR colours. We use this to identify PPN candidates, including three like IRAS 18455+0448. These are 19178+1206, 18470+0015 & 18123+0511.

Keywords. stars: AGB and post-AGB

The PPN phase begins when $dM/dt \rightarrow 0$ permanently, so the first diagnostics are the loss of LPV variability, and the presence of a detached shell. Time and radial evolution of the fossil shell add exceptionally red MIR colors and a B to K spectral type to the list of indicators. Since past searches for PPN depend on these “secondary”, evolved-state, criteria, they did not identify IRAS 18455+0448 as a young PPN, because it has a relatively blue (25-12) $\mu m = -0.275$. This object had a classic 1612 MHz OH/IR star spectrum when discovered that has since died (Lewis, Oppenheimer & Daubar 2001). Nevertheless it has an IRAS variability flag, *var*, that indicates a zero probability of it being a MIR variable, and its still extant OH mainline masers have a constant intensity. IRAS 18455+0448 is our prototype for a young PPN from a low-mass progenitor star.

Post AGB stars with detached shells are readily identified by their NIR colours (Lewis, Kopon & Terzian 2004), so we report here the results of a search for more young proto planetary nebulae in the Arecibo set of OH/IR stars with reliable 2MASS colours, (25-12) $\mu m > -0.4$, and *var* < 30%. This results in the 25 objects highlighted in figure 1, with the known planetary and proto planetary nebulae distinguished from the new objects, which are listed in Table 1. These scatter along the blue end of the NIR locus of OH/IR stars, with more dispersion than its other members. This is expected. If we assume a constant SED for the central star, simulations show that the NIR colors of a detached shell evolve along the locus toward its blue end (Lewis 2006), though if the SED evolves towards a B to K type, the corresponding NIR colors fall a little below the locus, and evolve parallel to it. Indeed it is clear from the group of known proto planetary nebulae at its blue terminus that these have evolved past the rest of the OH/IR stars to the notably bluer NIR colors of the stellar SED.

Our list of 25 includes IRC+10420, a hypergiant star with a detached shell that is unlikely to be a PPN. It also includes 19177+1333 & 19261+1849 that may be normal OH/IR stars with small *var* due to the particular epochs at which IRAS observed them, or else very young PPN. The new candidate PPN most like 18455+0448 is 19178+1206, which has lost its weak 1612 MHz feature, but still has a double-peaked 1667 MHz feature. A second method of identifying a young PPN from a low mass progenitor is to check the list for objects that have an expansion velocity $V_e < 12 \text{ km s}^{-1}$, as suggested by studies of the Arecibo OH/IR stars (Lewis, Eder & Terzian 1990). This highlights 18470+0015 as a red MIR star with bluer NIR colours than 18455+0448, and a $V_e = 4 \text{ km s}^{-1}$, and 18123+0511, as likely new PPN. Both fall below the NIR locus.

Table 1. New Candidate PPN from the Arecibo Set of OH/IR Stars

| IRAS | H-K | J-H | (25-12) μ m | (60-25) μ m | var % | note |
|-------------|-------|-------|-----------------|-----------------|-------|--------|
| 18123+0511 | 0.670 | 0.575 | -0.394 | -0.842 | 5 | |
| 18455+0448 | 1.989 | 1.774 | -0.275 | -0.783 | 0 | PPN |
| 18470+0015 | 1.689 | 1.618 | 0.009 | -0.531 | 15 | |
| 19177+1333 | 2.509 | 2.718 | -0.112 | -0.880 | 4 | OH/IR? |
| 19178+1206* | 0.728 | 1.965 | -0.038 | -0.672 | 1 | |
| 19227+1700 | 1.199 | 2.289 | -0.227 | -1.039 | 12 | |
| 19261+1849 | 2.593 | 4.055 | -0.259 | -0.748 | 9 | OH/IR? |
| 19319+2214 | 1.256 | 1.665 | -0.091 | -0.742 | 3 | |
| 19520+2759 | 1.607 | 2.053 | -0.003 | -0.175 | 16 | |

* no 1612 MHz emission now; *var* % \equiv IRAS probability of being a MIR variable

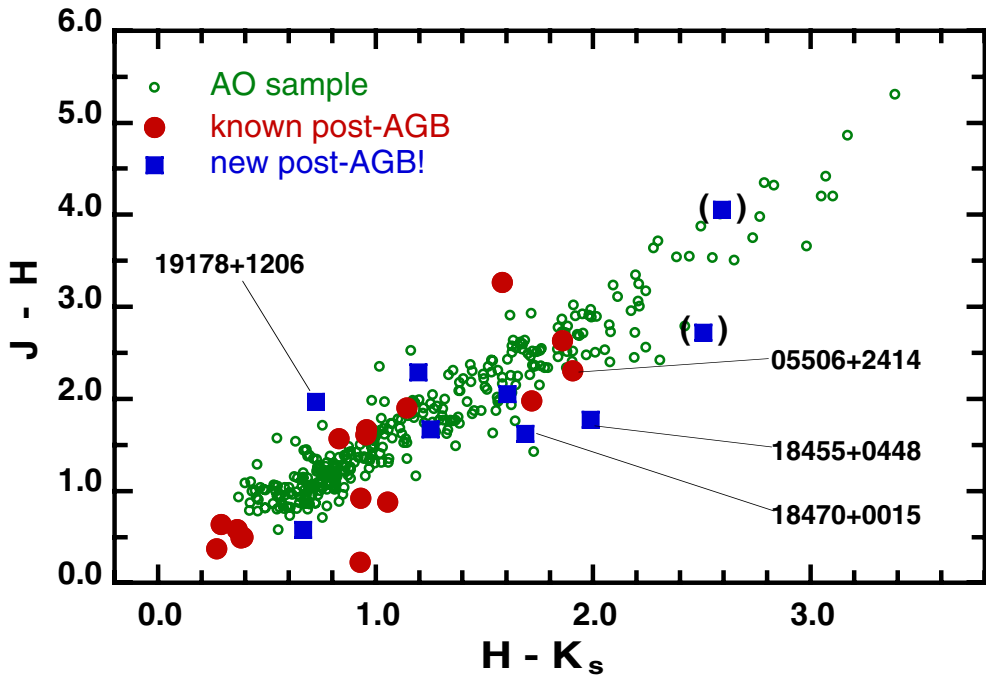


Figure 1. The 2MASS two-colour plot of Arecibo OH/IR stars with reliable fluxes. Those with an IRAS variability flag *var* < 30% of being MIR variables are marked with filled symbols: \circ for known PN & PPN, \square for new candidates.

Acknowledgements

This work is supported by the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

References

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