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POST AGB CANDIDATES

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ABSTRACT The characteristics of post AGB candidates identified from the IRAS data with optical counterparts are discussed. There seems to be an evolutionary sequence in the transition region from cooler K, G, F, A supergiant-like stars to hotter O–B types, evolving from the tip of the AGB towards young planetary nebula stage. A list of post AGB candidates is presented.

1. INTRODUCTION

All single stars initially less massive than about 8 $M_\odot$ and more massive than about 1 $M_\odot$ evolve onto the asymptotic giant branch (AGB) where they contain a very dense white-dwarf-like core composed of carbon and oxygen and have a very extended envelope. The AGB phase of evolution of intermediate and low mass stars is terminated by the ejection of most of the hydrogen-rich outer envelope, resulting in a planetary nebula (Iben and Renzini, 1983, Iben 1985). The superwind type of mass loss may lead to the formation of a planetary nebula and the termination of the AGB phase (Renzini, 1981). The Reimers mass-loss rate or low/slow mass rate may not be able to account for the formation of planetary nebulae. The post AGB stage of evolution may be preceded by mass-loss rate of the order of 10^{-4} to $10^{-5} M_\odot$ per year (Zuckerman, 1978). Renzini (1981) proposed that superwind type of mass loss (10^{-4} to $10^{-5} M_\odot$ per year) can take place for low and intermediate mass stars at the tip of the AGB phase. Theoretically and, in particular, observationally the transition stage between the AGB phase and the PN phase, i.e. the post AGB/proto-planetary stage, is least understood. Only recently it is becoming possible through IRAS data to recognize stars which may be in the transition region (Parthasarathy and Pottasch, 1986). It is likely that these objects are a small part of hitherto unseen phase of stellar evolution. Olnon et al (1984) noted that among the most exctreme OH/IR sources some are undergoing mass loss at a rate larger than $10^{-4} M_\odot$ per year and pulsate weakly or not at all. These objects appear to have reached the end of their evolution on the AGB. Habing et al (1987) made the hypothesis that non-variable OH/IR stars are more related to young planetary nebulae than to AGB stars. The non variable OH/IR stars have far infrared (IRAS) fluxes and dust shell characteristics similar to that observed in planetary nebulae. The non variable OH/IR stars may be described as the very early stage of post AGB objects.

2. HIGH GALACTIC LATITUDE A, F SUPERGIANTS

The presence of A and F type supergiants at high galactic latitudes was first noticed by Bidelman (1951). From the IRAS observations Parthasarathy and Pottasch (1986) discovered cold detached dust shell around high galactic latitude F and G supergiants. Their far infrared (IRAS) colors, flux distributions and the characteristics of dust shells are similar to that observed in planetary nebulae. Parthasarathy and Pottasch (1986) interpreted that the detached cold dust shells around the high galactic latitude F-G supergiants are the result of severe mass loss experienced by these stars during their AGB stage of evolution. They have suggested that the high galactic latitude supergiants evolved from low mass stars and they are not in post AGB stage of evolution. Lamers et al (1986) and Waelkens et al (1987) also found from IRAS data dust shells around high galactic latitude A supergiants HR 4049 and HD 213985. A-F-G supergiants at large distances from the galactic plane are very rare. Their high luminosities, high galactic latitudes and detached cold dust shells with characteristics similar to PN clearly suggest that they have suffered extensive mass loss in the recent past and therefore are most likely post AGB stars. These objects appear to be supergiants probably because the mass loss has caused the atmosphere to be in a temporarily extended state. Hrivnak, Kwok and Volk (1988) found IRAS 18095+2704 to be a high galactic latitude F supergiant with dust shell similar to HD 161796 and PN. The low and intermediate mass stars which have evolved upto the post AGB stage should also exist at low galactic latitudes. Further analysis of IRAS observations revealed few A, F, G, K stars with supergiant like spectra and have far infrared flux distributions, and colors, similar to that observed in planetary nebulae and high galactic latitude A, F, G, K supergiants (Pottasch and Parthasarathy 1988). Hrivnak, Kwok and Volk (1989) made photometric observations of some of the objects detected by Parthasarathy and Pottasch (1986) and Pottasch and Parthasarathy (1988). The $0.4 - 100 \mu m$ flux distribution clearly suggests that these objects have suffered extensive mass loss in the recent past and are most likely post AGB stars. The post AGB supergiant like stars detected from IRAS data are given in Table 1. IRAS 1540-5413 (LeBertre et al 1988) and IRAS 20056+1834 (Menzies and Whitelock (1988)) are M and G type supergiants and their IRAS data suggests that they are also post AGB stars. From IRAS colors Kwok et al (1987), van der Veen et al (1989), Garcia-Lario et al (1990), Manchado et al (1989) and Slijkhuis

(1992) have found several possible transition region objects. However most of these objects have very faint optical counterparts and some of them have no optical counterparts. From an analysis of IRAS fluxes of RV Tauri stars Jura (1986) suggested that they are in post AGB stage of evolution. Other post AGB candidates are CRL 2688 (F5 Iae) HD 44179 (Red Rectangle) (B8 Ie) and Roberts 22(A2 Ie).

3. B-TYPE EMISSION OBJECTS WITH FAR-IR COLORS LIKE PN

As post AGB stars/proto-planetary nebulae evolve into early stages of planetary nebulae, part of the dust shell begins to be ionized. The post AGB stars detected from IRAS data (Table 1) extended from non-variable OH/IR stars to M, K, G, F, A supergiant types. This sequence appears to represent the evolution of the post AGB stars towards hotter spectral types. From an analysis of IRAS data Parthasarathy and Pottasch (1989) detected few peculiar emission line (forbidden) B-type stars to show far infrared characteristics and detached cold dust shells similar to that observed in planetary nebulae. These are given in Table 2. Parthasarathy and Pottasch (1989) suggested that these stars (Table 2) are also post AGB stars and rapidly evolving towards young planetary nebulae.

4. TEMPERATURES, LUMINOSITIES AND MASSES OF DUST SHELLS

From the IRAS 12 μm to 100 μm flux distribution and [12 μm/25 μm], [25 μm/60 μm] and [60 μm/100 μm] colors the temperatures of the dust envelopes are estimated. Most of the objects given in Tables 1 and 2 have [12 μm/25 μm] $\sim$ 0.3 and the flux maximum is around 25 μm or 60 μm. These characteristics similar to that observed in the IRAS data of planetary nebulae (Pottasch et al 1984). Few objects like HD 101584 show relatively flat flux distribution from 12 μm to 100 μm (Parthasarathy and Pottasch 1986). In addition to detached cold dust shell few of these objects have relatively warm dust close to the star. The far infrared flux emitted by the dust shell around several of these stars (Tables 1 and 2) is nearly equal or slightly more than the flux emitted in the blue visual region by the central stars. The dust must absorb the optical radiation of the central stars. The dust must absorb the optical radiation of the central stars and re-emit it in far IR region. In spite of large amount of dust around these objects several of them are found to show no significant reddening of the fluxes in the ultraviolet, blue and visual regions (Parthasarathy, Pottasch and Wamsteker 1988). This result suggests that the dust particles are relatively larger than 2 to 3 μm. The dust temperatures T_d, luminosities L_{IR} and masses of the dust shells are estimated (for details see Parthasarathy and Pottasch, 1986, 1989., Potasch and Parthasarathy, 1988). In the far infrared colour-colour (F(60 μm)/F(100 μm) versus F(25 μm)/F(60 μm)) diagram these objects are located in the region of planetary nebulae. The masses of the dust envelopes are also similar to that observed in planetary nebulae. If the ratio of gas to dust mass is about 100, as it is in the interstellar medium, the total shell masses are of the order of 0.3 $M_{\odot}$ for HD 161796, HD 187885, HD 179821 etc (Parthasarathy and Pottasch 1986, Pottasch and Parthasarathy 1988). The accuracy of the dust mass determination is limited primarily by the uncertainties in distance, grain size and emissivity. The determination of accurate distances of the post AGB stars (Tables 1 and 2) is badly needed. The spectral type, luminosity class of several of these objects suggests high luminosities (M_v in the range −5 to −6.5). The total far infrared flux also suggests high luminosities for some of these objects. The minimum luminosity for the objects evolving from the tip of AGB towards left on the HR diagram is $M_{bol} \sim -3.7$. The far infrared luminosities of the dust shells of several of these objects are in the range of $10^3 L_{\odot}$ to $10^4 L_{\odot}$ (Parthasarathy, Pottasch 1986, 1989., Pottasch, Parthasarathy 1988). The uncertainties in the T_{eff} estimates of post AGB stars may be of the order of few hundred degrees (K)., T_{eff} can be estimated from the flux distribution in the optical region and from detailed spectroscopic analysis (Luck, Bond & Lambert 1990). The luminosities estimated from the spectral luminosity class may be uncertain as these objects are not supergiants in the real sense. The total fluxes in the optical and far IR clearly suggest higher luminosities for several of the post AGB stars and these stars have low spectroscopic gravities (Luck et al 1990). The spectral classification clearly suggests Ia, or I luminosity classes for most of these objects. The position of these objects in the HR diagram and the circumstellar dust shells, high galactic latitudes and high velocities of some of these stars clearly suggest that they are post AGB stars, evolving from the tip of the AGB towards left in the HR diagram. The central stars of some of the peculiar emission objects (Table 2) which are identified as post AGB stars from IRAS data are evolving towards hotter spectral types. Some have already produced considerable ionization in the emitted material (He 2-138, Tc 1, M-26 HD 51585 etc).

5. ULTRAVIOLET SPECTRA

In addition to the study of optical region spectra, analysis of the ultraviolet spectra of post AGB stars is important. As these objects have large circumstellar dust shells the 2200 Å feature will enable us to study the circumstellar reddening and dust grain properties. The UV region spectra may enable us to detect absorption and emission features attributable to dust, gas and molecules. The ultraviolet spectra of hot post AGB stars enable us to study the stellar continuum, mass loss, stellar wind profiles and emission lines etc. The ultraviolet spectra of the post AGB stars HD 161796 (F3Ib) and HD 187885 (F2I) was analysed by Parthasarathy, Pottasch and Wamsteker (1988). The UV spectrum of HD 161796 shows no excess UV flux attributable to a hot degenerate companion. From the UV spectrum the temperature of HD 161796 is found to be 6300 K. There is no evidence for significant metal deficiency. Except for the NIV] 1487 Å, line the rest of the transition region emission lines are weak. Inspite of the presence of large amount of circumstellar dust and 2200 Å region shows no evidence for circumstellar reddening. The dust grain size in the circumstellar dust envelopes of some of these stars is few microns and therefore causes mostly neutral extinction, or the dust may be distributed in the form of a disk. The grain ultraviolet extinction properties of post AGB stars HR 4049 and HD 213985 were investigated by Buss, Lamers and Snow (1989).

Parthasarathy, Pottasch and Wamstaker (1988) found the UV spectrum (1250 Å, to 1900 Å) of the post AGB stars HD 187885 to be peculiar. A broad emission feature with emission peak centered around 1580 Å, is present. A broad absorption feature nearby 100 Åwide centered around 1657 Å appears to be present. This absorption feature may be due to CI or due to quasimolecular absorption of the H_2. Parthasarathy et al (1992) obtained ultraviolet (IUE) spectra of Her 1013, Her 1357 and Her 1428. These are hot post AGB stars. Stellar UV continuum is detected in these three objects which suggests that these three objects are B type.

6. CO EMISSION

CO (J=1-0 and J=2-1) observations also indicate that these are post AGB stars with expanding molecular shells. Likkel et al (1987) detected HD 161796, SAO 163075, 89 Her in CO (J=1-0) and derived the mass loss rate of the order of $10^{-6} M_{\odot}$/year (scaled to a distance of 1 kpc). Zuckermann et al (1986) detected CO in SAO 96709 (HD 56126). The CO profile of HD 101584 is very remarkable with a total width of 300 km s^{-1} and several discrete peaks (Trams et al 1990, Loup et al 1990). The CO expansion velocity is 150 km s^{-1}. Post AGB stars with CO molecular envelopes are HD 56126 (SAO 96709), IRAS 07331+0021, IRAS 08005-2356, HD 53300, HD 101584, HD 161796, 89 Her, IRAS 187885 and HD 44179 (Red rectangle). Several of these stars (example 89 Her, HD 161796, HD 187885) show wings on the CO-profile. The presence of wings in the CO J=2-1 profile of HD 161796 extend from -53 to -13 km s^{-1} (Bujarrabal et al 1992). These wings probably correspond to a relatively high velocity outflow with bipolar symmetry. The expansion velocities derived from the CO-line profile range from 3 km s^{-1} for HD 44179 to 15 km s^{-1} for HD 161796. However the expansion velocities of the CO molecular envelopes of HD 179821 and HD 101584 are found to be 30 km s^{-1} and 150 km s^{-1} respectively (van der Veen et al 1992). The CO (J=1-0) emission is not detected from all the post AGB stars given in Table 1. The stars not detected in CO are likely evolving rather slowly towards hotter temperatures and they may have left the AGB relatively long time ago and therefore the CO emission is very weak or absent. The objects with CO emission have mass loss rates of the order of 10^{-5}– $10^{-6} M_{\odot}$/year. However the H_{α} profile of many of these stars suggests a mass loss rates of the order of $10^{-8} - 10^{-7} M_{\odot}$/year. Most of the AGB stars given in Tables 1 and 2 show P-cygni type H_{α} profiles. Some of these stars are found to show significant variations in strength and shape of the profile, some times H_{α} profile varies from violet absorption + emission in the red wing to emission in the violet wing and absorption line. Some of the post AGB stars given in Tables 1 and 2 have warm dust shells in addition to detached cold dust shell. The low colour temperatures of the dust envelopes imply that they had higher mass loss rate in the post than they have at present. Some of these post AGB stars appear to have more momentum in the expanding envelope than is available from the radiation of the star. For some of the post AGB stars $\beta = \dot{M} V_{exp} \frac{c}{L} > 1$. The value of $\beta < 1$ if the mass loss is driven by radiation pressure on dust. The value of $\beta > 1$ for some of the post AGB stars may be due to a recent decrease in luminosity. The low colour temperature of the circumstellar dust envelopes imply a decrease in mass loss rate, this would be likely to be accompanied by a luminosity decrease. The values of $\beta > 1$ indicate a rapidly changing stage.

7. OH MASER EMISSION

Recently OH maser emission was detected from HD 179821, HD 161796 Likkel (1989) HD 101584 (te Lintel Hekkert et al 1992) indicating that the circumstellar shells of these post AGB stars are oxygen rich. The OH maser emission spectrum of HD 101584 has a total velocity range of 84 km s^{-1} and shows two unusually broad emission features. Te Lintel Hekkert et al (1992) find that the OH masers in HD 101584 are located in a bipolar outflow. The outflow velocity of the OH molecule to be 42 km s^{-1}, which is considerably lower than the CO expansion velocity of $\sim$ 150 km s^{-1} (Trams et al 1990, Loup et al 1990). Several post AGB stars given in Tables 1 and 2 may have bipolar type circumstellar dust shells. The polarization measurements suggest non spherical nature of the circumstellar dust shells of these post AGB stars. The OH maser emission from HD 101584 appears to be similar to that of Roberts 22 and OH 231.8+4.2 which are considered to be proto-planetary nebulae. The central object of Roberts 22 is a A2Ie star (Allen et al 1980). The far infrared (IRAS) colours of Roberts 22 are similar to that of post AGB stars and planetary nebulae (Parthasarathy 1989). The bipolar structure seems to develop during the AGB mass loss phase or during the early phases of evolution from the tip of the AGB. The central stars of bipolar proto-planetary nebulae HD 44179 (Red rectangle) and CRL 2688 are also most likely post AGB stars similar to HD 101584 (Parthasarathy 1989). The bipolar and disk geometry of the dust envelopes around these objects may be the result of large angular momentum of the progenitor star or the central objects may be evolved binary systems embedded in thick disks formed from severe mass loss (Morris 1981, 1990, Parthasarathy 1989). Chapman et al (1992) found OH maser emission from IRAS 16122 - 5128 (F5Ia) te Lintel Hekkert et al (1988) found OH maser emission from Her 1475. Based on the IRAS data Parthasarathy and Pottasch (1989) suggested that Her 1475 is a post AGB star. In addition to OH maser emission HD 161796 and HD 179821 were found to show SiO emission (Bujarrabal 1992).

8. CARBON RICH OBJECTS

The near-infrared emission bands in HR 4049 and HD 44179 indicate that the circumstellar dust is carbon rich. The circumstellar dust shell of HD 56126 may be carbon rich - the presence of 21 μm feature and HCN (J=1-0) (Bujarrabal et al 1992) indicates that the dust shell is probably carbon rich. Also HD 187885 is probably carbon rich as indicated by the strength of the HCN line compared to CO (Bujarrabal et al 1992). The HCN strength and 2 μm feature of HD 56126 suggests that its circumstellar dust is carbon rich. However Parthasarathy, et al (1992) find the photospheric C/O ratio of HD 56126 is 0.57, which suggests that the photosphere is not carbon rich. Oxygen-rich dust surrounding a carbon-rich star can easily be explained, but the presence of strong oxygen in a photosphere surrounded by carbon rich dust is hard to explain. However some of the G type post AGB supergiants seems to have carbon rich photospheres (BD+54°2787, Hrivnak et al 1991). Detailed abundance analysis of such objects is important to understand the carbon-rich and oxygen rich post AGB stars and their circumstellar dust shells.

The object IRAS 07027-7934 appears to be a link between OH/IR stars and carbon-rich post AGB stars (Menzies and Wolstencroft 1990; Zijlstra et al 1991). On the basis of IRAS data Parthasarathy (1989) suggested that IRAS 07027-7934 is a post AGB star. Menzies and Wolstencroft (1990) found it to show nebular spectrum together with emission lines of C II and C III superimposed on a weak continuum. Menzies and Wolstencroft found it to be a young planetary nebula with a [WC 11] star. Recently Zijlstra et al (1991) found it to show a strong 1612 MHz OH maser, as well as weak CO emission. They suggest that the star has transformed from OH/IR star to carbon star within the last 500 years. OH 1612 MHz emission from carbon stars is very rare. A few carbon stars are surrounded by silicate dust shells but none of them shows a strong OH maser and they are AGB stars whereas 07027-7934 is already a PN. It is likely that the post AGB mass loss has speeded up the evolution and also has revealed the carbon enriched layers. The red shifted carbon lines in 07027-7934 suggest that it may be a binary (Zijlstra et al 1991). He 2-113 has a G-type companion, while IRAS 21282+5050 shows evidence of hot companion. Thus it may be that coolest [WC] stars are all binaris (Zijlstra et al 1991). Some of the post AGB stars (Table 1 example IRAS 22272+5435) are carbon rich and are binaries (Hrivnak et al 1991, 1992), such carbon rich post AGB stars may evolve into young PN with [WC] central stars.

9. ADDITIONAL POSSIBLE POST-AGB STARS

In table 3 additional 26 post AGB stars are given. Most of these objects have optical counterparts fainter than 10th magnitude. Their far-infrared (IRAS) colours are similar to PNe. We find some them to show F, G supergient like spectra similar to the post AGB stars given in Table 1., and some of them may be emission like objects or young PN similar to the post AGB objects given in Table 2. Spectroscopic and photometric observations of several objects given Tables 1, 2 and 3 are required.

10. POST-AGB BINARIES

Several post AGB stars have been found to show periodic radial velocity variations with periods of few hundred days (Hrivnak and Woodsworth 1992). The long period velocity variations suggest that some of the post AGB stars are binaries. However some of the periodic velocity variations may be due to pulsations. Post AGB stars which appear to be long period binaries are: BDe $+39^o$ 4926, HD 46703, HR 4049, HD 56126, IRAS 18095+2704, IRAS 22223+4327, BD $+54^o$ 2787, HD 179821, IRAS 19475+3119, IRAS 20004+2955, 89 Her. The binary nature of very metal poor post AGB stars (HR 4049, HD 52961, HD 44179, BD$+39^o$ 4926, HD 46703) may be able to account the nearly solar abundances of volatile elements (C, N, O, S, Zn etc) and depletion of refractory elements (Fe, Ca, Mg, Si, Al, Ti etc) in the photospheres of these stars. The capture or accretion of mostly the gas which is depleted in the refractory elements by the presently visible A-F supergiants from their disks may be one of the processes resulting in the observed peculiar composition of very metal poor post AGB stars (Mathis et al 1992). The depleted refractory elements are locked up in circumstellar dust grains (Bond 1991, Parthasarathy et al 1992).

11. CONCLUSIONS

From IRAS far-infrared observations warm and cold (detached) circumstellar dust shells have been detected in high galactic latitude A and F supergiants. CO emission and OH-maser observations, circumstellar dust shells, high galactic latitude, high velocities of some of these stars, and the chemical composition suggest that they are post AGB stars. From an analysis of IRAS far infrared observation several post AGB stars with characteristics similar to the high galactic latitude A, F supergiants have been found. The M, G, K, F, A supergiant-like post AGB stars which are all IRAS sources seem to represent an evolutionary sequence in the transition region evolving from the tip of the AGB towards young planetary nebula stage. These stars may represent a hitherto unseen phase of stellar evolution.

Several of these post AGB supergiants appear to be long period binary systems. The nearly normal abundances of CNO, S, Zn, etc. elements and depletion of refractory elements (Fe, Ca, Ti, Mg, Si, Al) suggest that the depleted refractory elements are locked up in circumstellar dust grains. The dust driven mass loss which drives out mostly the dust grains only or accretion of gas with depleted refractory elements may be able to account for the observed photospheric abundances.

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Table 1: Post AGB stars detected from IRAS data

	RA (1950)	DEC	V	Sp
SAO 40039	05 04 03.5	+48 20 16	9.8	F5
SAO 112630	05 17 00.6	+05 35 41	8.6	F8 I
IRAS 05341+0852	05 34 10.1	+08 52 23	11.7	F5 Ia
HD 44179	06 17 36.9	−10 36 51	8.8	B9I
HD 46703	06 32 51.7	+53 33 36	9.0	F8 Ia
HD52961	07 00 53.6	+10 50 42	7.4	FI
HD56126	07 13 25.4	+10 05 08	8.2	F5 I
HD53300	07 01 52.8	−05 13 55	8.1	Ao Ib
SAO173329	07 14 01.9	−23 21 39	9.7	F5
AI CMi	07 33 07.1	+00 21 40	8.8	G5 I
08005-2356	08 00 32.5	−23 56 16	11.5	F5 Ia
HR 4049	10 15 50.1	−28 44 32	5.5	B9 Ia
CPD-58°2154	10 21 32.5	−59 16 53	8.7	G5 I
HD 95767	11 00 03.6	−61 53 41	8.8	Fo Ib
HD 101584	11 38 33.9	−55 17 49	7.0	Fo Ia
CPD-535072	12 17 33.3	−53 38 49	9.3	A9 Ia
HD 108015	12 22 12.1	−46 52 29	8.0	F3 I
HR 4912	12 53 48.6	−26 11 22	6.6	F3 Ia
HD 114855	13 11 05.3	−54 25 41	8.4	F5 Ia
HD 133656	15 03 59.4	−48 06 22	8.2	A2 I
HD 137569	15 24 01.0	−14 52 04	7.9	B5 III
IRAS 1540-5413	15 40 49.3	−54 14 30		M7 I
HD 142527	15 53 16.8	−42 10 46	8.36	F6 III
HD 143006	15 55 38.9	−22 48 45	9.5	G5 e
HD 144432	16 03 53.7	−27 35 08	8.2	Fo IIIe

Table 1: continued

	RA (1950)	DEC	V	Sp
HD 145718	16 10 13.3	−22 21 29	9.0	A8 III
−59°6723	16 20 40.5	−59 56 38	9.8	B8 Ia
SAO 209008	17 32 41.1	−33 24 08	8.5	G2 Ia
−62°5428	16 39 58.8	−62 47 54	10.0	A7 Ia
HD 158616	17 27 59.8	−11 19 55	9.9	F8
HD 161796	17 43 40.7	+50 03 47	7.0	F3 I
89 Her	17 53 24.1	+26 03 24	5.5	F2 Ib
SAO 85766	18 06 16.3	+24 10 10	8.8	A5
IRAS 18095+2704	18 09 30.9	+27 04 28	10.4	F3 Ib
HD 168625	18 18 25.5	−16 23 56	8.4	B8 Ia
HD 172324	18 36 15.4	+37 23 24	8.2	B9 Ib
HD 172481	18 38 28.2	−27 59 55	8.3	F2 Ia
HD 179821	19 11 25.0	+00 02 18	8.3	G5 Ia
IRC+10420	19 24 26.3	+11 15 09	11.2	F8 Ia
HD 331319	19 47 32	+31 19 38	9.9	F3 Ib
HD 187885	19 50 01.5	−17 09 38	9.0	F3 I
V 1027 Cyg	20 00 26.3	+29 56 50	8.9	G7 Ia
IRAS 20056+1834	20 05 40.2	+18 34 10	12.5	Go I
AFGL 2688	21 00 19.9	+36 29 45	14.0	F5 Ia
+54°2787	22 27 13.2	+54 35 41	9.2	G5 I
HD 213985	22 32 45.9	−17 31 00	9.0	A2 Ia
BD+39°4926	22 43 55.3	+39 50 37	9.2	FI
IRAS 23304+6147	23 30 26.7	+61 47 15	13.0	G5 I

Table 2. Post AGB stars detected from IRAS data

	RA (1950)	DEC	V	Sp
HD 51585	06 55 37.6	+16 23 32	11.5	BQ[ ]
WRA 488	10 00 09.9	−58 57 43	13.1	
Hen 373	10 08 1403	−56 47 18	12.5	Be
Hen 401	10 17 48.6	−59 58 23	12.5	Be
Hen Car	10 21 07.2	−59 22 16	8.11	B2 e
Hen 591	11 06 33.5	−60 26 35	10.7	Be[ ]
Hen 847	12 58 24.9	−48 37 15	11.4	Be
Hen 892	13 18 32.7	−69 22 29	9.6	Be
-55^o 5588	13 26 39.8	−55 51 24	10.7	Be
Hen 1013	14 33 07.4	−64 35 01	10.9	Be
CPD-53^o5736	14 48 50.9	−54 05 21	10.5	Be
IRAS 15154-5258	15 15 27.7	−52 58 57	13	
HD 137569	15 24 01.0	14 52 04	7.9	B5 III
HD 141969	15 51 19	−66 00 23	11.93	BQ
WRA 1537	16 45 30.2	−34 55 44	13	Be
M2-9	17 02 51.8	−10 04 31	13.7	B[e]
Hen 1336	17 04 06	−27 09 43	12.17	Be
HD 326971	17 06 54.4	−41 49 07	11.0	Be
Hen 1347	17 07 28.2	−18 45 20	9.5	Be
Hen 1357	17 11 56	−59 26 06	10.95	Be
Hen 1428	17 31 11.8	−49 24 33	10.68	Be
HD 161044	17 41 52.4	−46 04 13	10.5	BQ e
Hen 1475	17 42 18.8	−17 55 36	11.0	Be
HD 316248	17 42 45.1	−30 10 57	11.5	BQ [ ]
SAO 209306	17 46 02.0	−31 14 23	7.9	Bo II
HD167402	18 13 06.2	−30 08 40	9.0	Bo II
IRAS 18442-1144	18 44 16.4	−11 44 31	9.3	Be
LS IV-12^o111	19 59 02.1	−12 49 44	11.0	OB

Table 3. New possible post AGB stars
(The optical counterparts are fainter than 10th magnitude)

IRAS	IRAS	IRAS	IRAS
04296 +3429	07430 +1115	14132 −5839	20000 +3239
05113 +1347	08187 −1905	14150 −6718	20572 +4919
05238 −0626	08355 −4027	17112 −1918	22223 +4327
05381 +1012	08574 −5011	17415 −2801	22574 +6609
07131 −0147	09032 −3953	17588 −2340	23304 +6147
07227 −1320	11339 −6004	18020 −2037	
07253 −2001	12238 −4907	18063 −1943	