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Spectroscopy of IRAS sources with far IR colours similar to those of planetary nebulae

B. Eswar Reddy and M. Parthasarathy
Indian Institute of Astrophysics, Bangalore 560 034

Abstract. Optical candidates of 17 unidentified IRAS sources with far-infrared colours similar to planetary nebulae have been detected on sky survey plates. Low resolution CCD spectra of seven optical candidates suggests that they are post AGB A-F-G supergiants. Their location in the HR diagram and the presence of detached cold dust shells with far-infrared colours similar to planetary nebulae suggests that they are low mass stars and have experienced severe mass loss in the recent past during their AGB stage of evolution.

Key words : planetary nebulae—stellar evolution—mass loss

1. Introduction

Planetary nebulae are strong infrared emitters. The IRAS far-infrared fluxes of planetary nebulae show flux maximum around 25 μm or 60 μm indicating the presence of detached cold (100 K to 300 K) dust shells. At present 1200 to 1500 planetary nebulae are known. IRAS data may contain few thousands of these objects which have not yet been identified and studied. In fact all the transition region objects (i.e. the objects in the evolutionary stage from the tip of the AGB to planetary nebula stage) are expected to have circumstellar dust shells with far-infrared colours similar to planetary nebulae. Optical identification and study of IRAS sources with far infrared colours similar to planetary nebulae will enable us to discover and understand the early stages of planetary nebula developments. The evolutionary life time of star (in the transition region) from the tip of the AGB to young planetary nebula stage is relatively short. Therefore, we expect to find in this region objects in early stages of post AGB evolution. Using the IRAS colour-colour diagrams (using the ratios of 12 μm, 25 μm, and 60 μm IRAS fluxes) it is possible to identify IRAS sources with far-infrared colours similar to planetary nebulae. This is because the far infrared colours of planetary nebulae are unique. In the far infrared colour-colour diagram there is no overlap between planetary nebulae with galaxies, HII regions and or normal stars and also young stellar objects. The IRAS sources with far infrared colours similar to planetary nebulae include planetary nebulae, post-AGB A, F, G, K supergiants, non variable OH-IR stars and post-AGB stars completely obscured by the circumstellar dust envelopes. The unidentified IRAS objects with far-infrared colours similar to planetary nebulae are either evolving into PN or

related to this stage of evolution. Also the fact that some bright supergiants have far-infrared (IRAS) colours similar to planetary nebulae was first pointed out by Parthasarathy & Pottasch (1986). These stars are high galactic latitude A-F supergiants and the presence of detached cold dust shells with far infrared colours similar to planetary nebulae suggests that they have suffered extensive mass loss in the recent past during their AGB stage of evolution. The current understanding is that now they are in post-AGB stage of evolution. Since 1986 a number of similar objects have been found and studied (Pottasch & Parthasarathy 1988; Hrivnak *et al.* 1989; Van der veen *et al.* 1989; Likkel *et al.* 1987). In this paper we report the optical identification and spectroscopic detection of IRAS sources with far-infrared colours similar to post AGB stars and planetary nebulae.

2. Observations

From an analysis of IRAS data we have selected unidentified IRAS sources with far-infrared colours similar to planetary nebulae. Our selection criteria is the flux ratios F12 μm/F25 μm < 0.5 and F25 μm/F60 μm > 0.33. Then we made the optical identification of these sources on the sky survey plates. The selected IRAS sources with the above mentioned flux ratios and with optical counter parts are being observed with the CCD Cassegrain spectrographs on the 1 m and 2.3 m telescopes at VBO. We are also observing these sources with a CCD-camera in *BVRI*.

3. Analysis

The IRAS fluxes of the sources and their approximate magnitudes of the optical counter parts are given in table 1. So far we have been able to obtain CCD low resolution spectra of seven objects. The optical counter parts of all these objects are stellar in appearance. Their spectral types and luminosity classes are estimated from a comparison of their spectra with the spectra of standard stars. The Hα profile in the spectra of some of these stars indicates the presence of emission which is also one of the characteristics of post A-F-G supergiants. The optical region spectra of seven sources indicates that they are A-F-G supergiants (table 1). IRAS 08187 – 1905 and IRAS 05341 + 0852 are found to be F6I supergiants. We have estimated the temperatures, luminosities, masses and radii of the dust shells around these two stars (table 2). The method of analysis and equations used are given in Pathasarathy & Pottasch (1986). The dust shell characteristics of these stars are similar to that of high galactic latitude post-AGB A-F supergiants and planetary nebulae. Geballe & van der veen (1990) discovered remarkable 3 μm emission features in IRAS 05341 + 0852. They found that the profiles and relative strengths are highly abnormal in particular the 3.4 μm feature is as intense as the unusually narrow 3.3 μm feature. It is generally accepted that the 3.3 μm emission feature is the fundamental vibrational stretching mode of CH bands either in large molecules such as PAH or in very small dust grains. It is likely that IRAS 05341 + 0852 is a carbon rich post AGB F6 supergiant.

4. Conclusions

Optical counterparts of 17 unidentified IRAS with far-infrared colours similar to planetary nebulae have been identified on the sky survey plates. Low resolution CCD spectra and CCD *BVRI* photometric observations of several of these optical counterparts have been obtained.

Table 1. New post AGB stars detected from IRAS data

Name	*mv*	Sp. type	IRAS fluxes (Janskies) 12 μm	25 μm	60 μm	100 μm	T_d (°K)	*F* total *IR* $\times 10^{-12}$ w/m^2
IRAS02143 + 5852	~11	F0V	5.91	18.11	5.31	—	157	3
IRAS05113 + 1347	~12	GI	3.79	15.35	5.44	—	145	2.33
IRAS05215 + 0225	9.6	A5I	0.77	2.75	2.86	1.47	95	0.49
IRAS05238 + 0626	~11	F2I	0.73	1.76	1.26	—	143	0.35
IRAS05284 + 1945	~15	—	4.18	9.01	3.29	—	161	0.52
IRAS05341 + 0852	11	F6I	4.52	9.89	3.87	—	161	1.59
IRAS05381 + 1012	~14	—	0.85	2.95	1.37	—	145	0.50
IRAS06530 + 0213	~14	—	7.40	26.52	11.91	03.7	145	3.60
IRAS07227 + 1320	~15	—	2.48	5.01	2.69	—	155	0.90
IRAS 07253 – 2001	~11	—	6.33	15.23	05.95	—	160	2.20
IRAS08143 – 4406	~12	F8I	0.61	9.31	5.96	—	115	2.30
IRAS08187 – 1905	8.9	F6I	0.72	17.69	12.09	3.53	110	2.54
IRAS17291 – 2402	~13	—	2.11	9.33	22.73	11.58	75	2.00
IRAS17441 – 2411	~13	—	42.86	191.13	106.09	—	135	10
IRAS20266 + 3856	~14	—	—	16.40	15.02	—	100	2.3
IRAS20406 + 2953	~15	—	12.52	68.37	49.36	12.58	160	11.4
IRAS23304 + 6147	~13	—	11.39	59.03	26.03	—	135	9.00

Table 2. Luminosities, temperatures, radii and masses of dust envelopes

Name	T_d (°k)	$F_{total}IR$ $\times 10^{-12}$w/m^2	$F_{optical}$ $\times 10^{-12}$w/m^2	*d*(Kpc)	$Md/M_\odot$ $\times 10^{-5}$	$Rd/R_\odot$ $\times 10^5$
IRAS 08187–1905	111	2.5	3.9	6	53	3.4
IRAS 05341+0852	161	1.59	—	7	7.6	0.94

The optical candidates have been found to be A-F-G supergiant like stars similar to the post AGB A-F-G supergiants (Parthasarathy & Pottasch 1986). We conclude that the seven IRAS sources with far IR colours similar to planetary nebulae listed in table 1 show A-F-G supergiant like spectra and are most likely post AGB supergiants. Near infrared photometry, detection of variability, chemical composition analysis and CO millimeter wave observations will enable us to further understand their evolutionary status.

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