

## Post-AGB A-F supergiant stars

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**Abstract.** We have searched the IRAS PSC for dust shells around A-F supergiant stars similar to the high galactic latitude A-F supergiants with circumstellar dust shells. We have found that HD 114855 (F5Ia), HD 158616 (F8I), SAO 173329 (F5I), V718 Sco (A8III), HD 53300 (A0Ib), HD 331319 (F3Ib), SAO 40039 (A4Ia) to be IRAS sources with far infrared colours and flux distribution similar to those of planetary nebulae. These stars have detached cold dust shells. Temperatures, masses, radii and luminosities of the dust shells are derived. The dust shell characteristics suggest that these stars have suffered severe mass loss in the recent past during their AGB stage of evolution. Their present position in the H-R diagram suggests that they are evolving towards left into the region of planetary nebulae.

*Key words* : supergiants—stellar evolution

### 1. Introduction

The fact that some bright supergiant stars have planetary nebulae colours in the far infrared was first pointed out by Parthasarathy & Pottasch (1986). Parthasarathy & Pottasch discovered detached cold circumstellar dust shells around high galactic latitude F supergiants. Their far-infrared (IRAS) colours and flux distributions are similar to that observed in planetary nebulae. They interpreted that the detached cold dust shells around the high galactic latitude F and G supergiants are the result of severe mass loss experienced by these stars during their AGB stage of evolution. They have also suggested that the high galactic latitude supergiants evolved from low mass stars and they are now 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, HD 213985. A-F-G supergiants at large distances from the galactic plane are very rare. Their high luminosities, high velocities, high galactic latitudes and detached cold circumstellar dust shells with characteristics similar to planetary nebulae suggest that they have suffered extensive mass loss in the recent past and they appear to be supergiants probably because the mass loss has caused the atmosphere to be in a temporarily extended state. Hrivnak, Kowk & Volk (1988) found IRAS 18095 + 2704 to be a high galactic latitude F supergiant with dust shell similar to that of a PN and HD 161796 (Parthasarathy & Pottasch 1986). Since 1986 a number of similar stars have been

found and studied (Pottasch & Parthasarathy 1988; Hrivnak *et al.* 1989; Van der veen *et al.* 1989; Likke *et al.* 1987). All these stars seem to form a class of objects not associated with the massive young supergiants. The post AGB supergiants are found to extend from K supergiants to B supergiants (Parthasarathy 1990). Parthasarathy (1990) suggested that the K to B post AGB supergiants represent the evolutionary sequence in the transition region, evolving from the tip of AGB towards left in the H-R diagram into the region of planetary nebulae. The detection and study of post AGB supergiants of various spectral types is important to further understand their evolutionary status. In this paper we report the detection of nine post-AGB A, F-G supergiants.

## 2. IRAS measurements

From an analysis of IRAS data we have found that HD 114855 (F5Ia), HD 158616 (F8I) SAO 173329 (F5I) V718 Sco (A8III), HD 53300 (A0Ib), HD 331319 (F3Ib), SAO 40039 (A4Ia), and SaO 112630 (G0I) are IRAS sources. The 12  $\mu\text{m}$ , 25  $\mu\text{m}$ , 60  $\mu\text{m}$  and 100  $\mu\text{m}$  fluxes of these objects are given in table 1. We have also obtained optical region low resolution CCD spectra of some of these stars.

Table 1

Name	<i>mv</i>	Sp. type	IRAS fluxes (Janskies)			
			12 $\mu\text{m}$	25 $\mu\text{m}$	60 $\mu\text{m}$	100 $\mu\text{m}$
HD114855	8.4	F5Ia	—	2.21	7.46	5.18
HD158616	9.9	F8I	3.54	2.92	1.54	—
SAO173329	9.7	F5I	2.29	1.84	0.7	—
SAO209008	8.5	G2I	5.77	28.65	—	—
V718Sco	9.0	A8III	5.72	5.92	4.91	3.37
HD5330	8.1	A0Ib	0.75	0.37	0.43	2.71
HD331319	9.9	F3Ib	0.62	37.94	55.46	14.51
SAO40039	9.0	AI	—	7.21	19.96	10.68
SAO112630	8.6	G0I	0.61	4.4	13.85	9.10

## 3. Analysis

The far-infrared colours and flux distribution of the nine stars given in table 1 are similar to that of planetary nebulae and post AGB A-F supergiants. The spectral types and luminosity classes of these objects given in the literature (table 1) clearly suggests that in the optical region these stars show A-F-G supergiant like spectra similar to the high galactic latitude post-AGB A-F supergiants. None of these stars are in the star forming regions and they are not members of any known star cluster. The detached cold circumstellar dust shells around these stars suggests that they have experienced severe mass loss in the recent past. From an analysis of far infrared (IRAS) flux distribution and colours we have derived the temperatures, luminosities, masses and radii of the circumstellar dust shells (table 2). The method of analysis and equations used are described in Parthasarathy and Pottasch (1986). The characteristics of the dust shells around these nine stars are similar to that detected planetary nebulae and

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

Name	$T_d$ (°K)	$F_{\text{total IR}}$ $\times 10^{-12}$ w/m <sup>2</sup>	$d(\text{kpc})$	$L_{\text{IR}}/L_{\odot}$	$Md/M_{\odot}$ $\times 10^{-4}$	$Rd/R_{\odot}$ $\times 10^3$
HD114855	70	0.43	3	90	8	100
			4	160	15	200
HD158616	195	0.6	5	350	0.4	0.5
			3	970	0.5	0.12
SAO173329	213	0.37	4	140	1.5	0.15
			2	35	2.0	0.4
SAO209008	137	1.7	3	360	1.0	12
			5	1000	2	33
V718Sco	153	1.2	0.3	2.5	0.06	0.14
			2	110	0.4	6
HD5330	53	0.12	3	2.5	1	56
			4	4	2	82
HD331319	153	5	6	4200	5	118
SAO40039	75	1.7	2	160	0.8	61
			5	1000	1	381
SAO112630	87	1.1	3	230	4	1.6
			4.7	560	2.5	4

post-AGB A-F supergiants. In the IRAS colour-colour diagram also these nine objects are in the region occupied by planetary nebulae and post-AGB A-F supergiants.

The optical spectrum of SAO 40039 is similar to that of A 4-5 I supergiant star. The optical spectrum V718 Sco is similar to that of A8-Fo III giant. The H $\alpha$  profile's narrow absorption core and emission in the wings of V718 Sco shows the presence of gaseous shells or disc around the star. Some of the stars given in table 1 show H $\alpha$  emission in the wings and also asymmetric or shell type profiles which is also a characteristics feature of post AGB supergiants.

#### 4. Conclusions

The stars HD 114855 (F5Ia), HD 158616 (F8I), SAO 173329 (F5I), V718 Sco (A8III), HD 53300 (AoIb), HD 331319 (F3Ib) and SAO 40039 (A4I) are found to be IRAS sources. Analysis of far-infrared flux distribution and colours suggest that they have detached cold circumstellar dust shells with characteristics similar to planetary nebulae. The presence of dust shells around these nine stars suggests that they have experienced mass loss in the recent past during their AGB stage evolution. It is likely that these nine stars are additional post-AGB A-F supergiant stars.

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