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Detached cold dust shells around yellow variable supergiants TW Aql, AI CMi, V 925 Sco and related stars

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Abstract. TW Aql, AI CMi, V 925 Sco, ST Pup, AX Sgr, AD Aql, V1027 Cyg are yellow variable supergiants. We find these stars to be far-infrared (IRAS) sources with flux maximum around 25 μm. Analysis of the IRAS fluxes shows the presence of detached cold circumstellar dust shells. Some of these stars are yellow semiregular variables and also show under abundance of metals. TW Aql, AI CMi, V 925 Sco have far-infrared IRAS colours similar to those of planetary nebulae. V 925 Sco is near the cepheid instability strip.

The detached cold dust shells around these stars suggest that they experienced severe mass loss in the recent past. Until now these stars were considered to be massive supergiants. V 925 Sco was considered as a very long period cepheid. We conclude that TW Aql and AI CMi are low mass stars in the post-AGB stage of evolution. The evolutionary status of V 925 Sco is not clear. However the presence of detached cold dust shell with far-IR colours similar to PN suggest that it may also be a low mass star in post AGB stage of evolution.

Key words : supergiants—stellar evolution

1. Introduction

The SRd type (Yellow semiregular) variable stars are semiregular variable giants and supergiants of spectral types of F, G, K., sometimes with emission lines in their spectra. Amplitudes of light variations are in the range from $0^m.1$ to 4^m, the range of periods is from 30^d to 1100^d. The SRd variables are about 5 to 30 times more metal poor than the sun and have kinematics of an old disk or halo population. These stars are often called yellow semiregular variables as discussed by Joy and Stothers are high velocity stars $|V_R|$ 70 km s^{-1} and a velocity dispersion in the Z-direction typical of a halo population. The yellow semi regular variables are redder than RV Tau stars and have stronger and longer Balmer emission lines and are metal poor low gravity, luminosity class Ib stars. These stars show greater variability in their periods. They show only a single drop in light but many have dips or still stands about halfway through the decline. The RV Tauri stars and yellow semiregular variables have some common characteristics. However the evolutionary connection between them is not clear. From the evolution point of view they may be low mass post-AGB objects. One of the characteristics of RV Tauri stars is the presence of relatively thick circumstellar dust shells (Jura 1986). If yellow semiregular variables are also in post-AGB stage of evolution then we except to see circumstellar dust shells around some of them. We searched the IRAS point source catalogue for the presence of circumstellar dust shells around yellow semiregular variables. In this paper we report the detection of detached cold circumstellar dust shells around the yellow semiregular variables TW Aql, AI CMi and related stars.

2. IRAS measurements

We have searched the IRAS PSC for infrared sources associated with yellow semiregular variables and related stars. We have found TW Aql, AI CMi, V925 Sco, AX Sgr, AD Aql and V 1027 Cyg to be IRAS sources. We have used the 12 μm, 25 μm, 60 μm and 100 μm fluxes of these objects to study the characteristics of their circumstellar dust shells (table 1).

Table 1

Name	*mv*	Sp.type	IRAS fluxes (Janskies)			
			12 μm	25 μm	60 μm	100 μm
TW Aql	9.9-10.7	K7I	0.27	5.26	11.06	3.37
AICMi	8.8-10.6	G5I	15.4	68.1	18.2	3.5
V925Sco	8.6	G2Ia	5.8	28.6	—	—
STPup	9.66	G2Iab	3.5	6.0	1.2	—
AXSgr	9.62	G5Ia	37	51	33	—
ADAql	10.9	G8[I]	2.5	2.7	—	—
V1027Cyg	8.6-8.8	G-KI	32	37	4.6	—

3. Analysis

The far infrared flux distribution and colours are used to derive the temperature, luminosity, mass and radii of the dust shells (table 2). The method of analysis and equations used are described earlier by Parthasarathy & Pottasch (1986).

TW Aql

TW Aql is yellow semiregular variable Go I-Ko I with period around 96 days. Cycles of 65^d or 95^d are observed during different time intervals. Dawson (1979) from DDO photometry derives $E(B-V) = 0.15$, $T_{eff} = 4950$, $\log g = 1.1$, $M_V = -4.8$ and the distance $d = 3.64$ kpc. Alcolea & Bujarrabal (1991) gives a distance of 4.3 kpc. Fix & Claussen (1984) and Planesas *et al.* (1991) detected main line OH emission from TW Aql which clearly suggests that the circumstellar dust shell is oxygen rich. The far infrared IRAS fluxes show flux maximum at 60 μm. The far infrared colours of TW Aql are similar to that of high galactic latitude post AGB F supergiants (Parthasarathy & Pottasch 1986) and planetary nebulae. The presence of detached cold dust shell around TW Aql with far IR colours similar to planetary nebulae suggests that TW Aql suffered significant mass loss in the recent post during the AGB stage of evolution. These results suggest that it is a low mass star in post-AGB stage of evolution.

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

Name	T_d (°k)	F_{total} IR × 10^{-12} w/m^2	d(Kpc)	$L_{IR}/L_{\odot}$	$Md/M_{\odot}$ × 10^{-4}	$Rd/R_{\odot}$ × 10^5
TW Aql	87	1.2	2	110	2.3	3
			5	700	3	5
AICmi	151	8	3	1700	1.7	1
			4	3000	3	4
V925Sco	139	2.12	3	460	1.1	1.2
			5	1300	3	2
STPup	187	1.96	2	200	0.5	0.3
			4	1000	2	0.6
AXSgr	193	7	3	1500	0.05	1
			5	4200	0.1	2
ADAql	207	0.52	4	200	0.03	0.2
			7	600	0.1	0.4
V1027Cyg	213	7.7	1	200	0.02	0.3
			3	2000	0.2	0.5

AI CMi

The third edition of the GCVS listed this objects variability type as 'L' ? or SRd (yellow semiregular variable). MacConnell & Bidelman (1976) find the spectral type of AI CMi to be G5Ia. Eggen (1983) carried out photoelectric photometry of AI CMi and finds it to be a semiregular variable with a typical cycle length of 80-100 days. With an amplitude of about 1 mag, and large changes from cycle to cycle. Eggen (1983) finds $E(b-y) = 0.10$. Eggen suggests that the large value of $b-y$ may be due to circumstellar reddening. *JHK* photometry indicates the presence of circumstellar dust (Eggen 1983). The IRAS flux distribution and colours of AI CMi are similar to that of post AGB F-G supergiants and planetary nebulae. The flux maximum is at 25 µm. The far-infrared flux distribution clearly suggests the presence of detached cold dust shell. The dust shell parameters suggest that AI CMi is a post AGB star. The circumstellar dust shell is the result of mass loss experienced by AI CMi during its AGB stage of evolution. Luck & Bond (1989) find it to be metal poor ([Fe/H] = –1.0) and also showing mild underabundance of s-process elements. The [Fe/H] = –1.0 suggests that it is a low mass star belonging to the halo or thick disk.

V925 Sco (HD 159378)

V925 Sco is a G2Ia supergiants. It is situated near the blue edge of the Cepheid instability strip, shows a light variation with a period of 70 to 90 days and a maximum amplitude of $0^m.12$ (van Genderen & The 1978). van Genderen (1980) suggested that it may not be a long period Cepheid. V925 Sco shows far infrared flux maximum around 25 µm indicating the presence of a detached cold dust shell. It is likely that V925 Sco is a post AGB star. It may not be a massive Pop I long period Cepheid.

ST Pup is a population II cepheid. The presence of relatively warm dust shell suggests that the star has experienced mass loss in the recent past. AD Aql may belong to the RV

Tau type stars. It's spectral type and luminosity class are uncertain. Spectroscopic study of this star is needed.

AX Sgr and V1027 Cyg show warm dust shells. The flux maximum is at 12 μm which may be due to silicate emission. The evolutionary status of these stars is not clear and they may be similar to 89 Her.

4. Conclusions

Some of the yellow semiregular variables show detached cold circumstellar dust shells which indicates severe mass loss in the recent past during their AGB stage of evolution. TW Aql, AICMi, V925 Sco are most likely low mass stars in post-AGB stage of evolution. The evolutionary connection between these stars and post AGB A-F supergiants and RV Tauri stars is not clear. May be some of the post AGB A-F supergiants have gone through the phase of yellow semiregular variable and RV Tauri star stages.

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