ON THE RADII OF Ap AND Am STARS

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Abstract. The radii of several Ap and Am stars have been compared with those of the normal A stars of the Main Sequence. Though the brighter Ap stars have a little larger radii than the Main-Sequence stars, they may not be much different from those of the slightly evolved normal A stars. The Am stars have radii with which they appear to be merging with those of the cooler A stars of the Main Sequence. The Ap stars have radii predominantly in the range of 1.8 to 3.4 $R_\odot$, while the Am stars are mainly concentrated between 1.8 and 2.2 $R_\odot$.

1. Introduction

The radii of several Ap and Am stars have been estimated following the procedure adopted earlier by Babu (1977), which is based on the method described by Gray (1967) using the relation

$$R/R_\odot = 44.33 \times 10^6 (F_\nu/\mathscr{F}_\nu)^{1/2} p^{-1}\,, \tag{1}$$

where F_ν is the monochromatic flux received from the star at the Earth and $\mathscr{F}_\nu$ is that emitted by the star. It is evident that the accuracy of these determinations depends mostly on that of the parallax. The values of $R/R_\odot$ are tabulated in our earlier paper (Babu and Shylaja, 1981) and in the following discussion, we have attempted to see whether the radii of Ap and Am stars in any way, differ from those of the normal A stars.

2. Discussion

The above-mentioned tabulation in our earlier work shows that the radii of Ap and Am stars are between 1.5 to 5.0 $R_\odot$. The histogram in Figure 1 indicates that there are predominantly more Ap stars in the range 1.8 to 3.4 $R_\odot$ with a fair sprinkling of some larger sized ones, while the Am stars are mainly concentrated between 1.8 and 2.2 $R_\odot$, having hardly any at values $> 2.6\,R_\odot$. Though the overall range of our estimations show a good agreement with that given by Catalano and Strazzulla (1975) for Ap stars, their distribution for the radii shows a predominancy from 1.75 to 2.75 $R_\odot$ only, with a negligible number at radii $> 3.25\,R_\odot$.

Since it is known that the radius of a given star is directly related to its absolute magnitude, we have plotted these two parameters in Figure 2. The filled circles, open circles and filled triangles are, respectively, the Ap, normal A and Am stars observed by us (loc. cit.). The crosses are the Main-Sequence stars, taken from the work of Underhill *et al.* (1979) for stars earlier than B9, while those of the later classes are from Gray (1967, 1968). In this figure, the normal, peculiar A and Am stars appear to be

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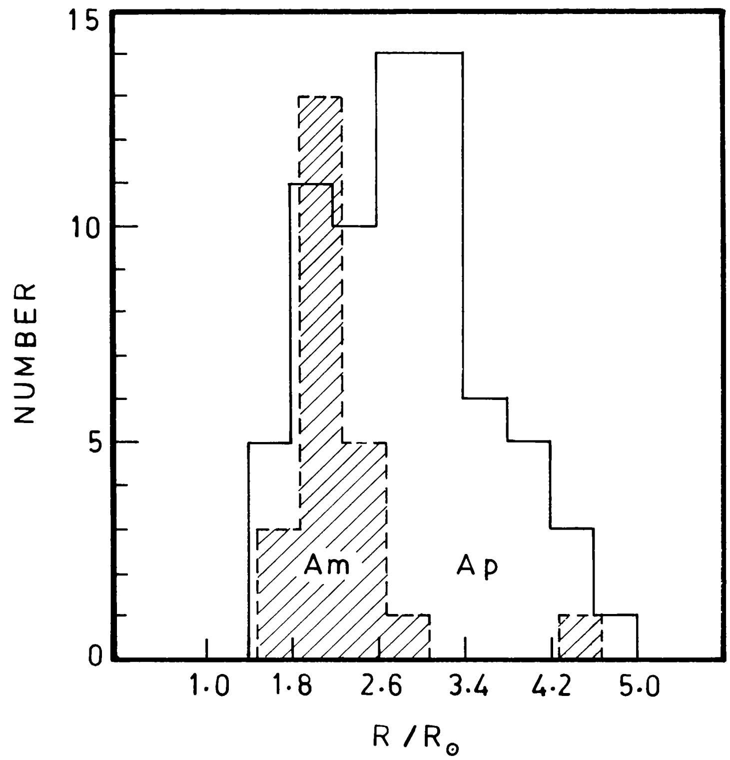

Fig. 1. The distribution for the radii of Ap and Am stars.

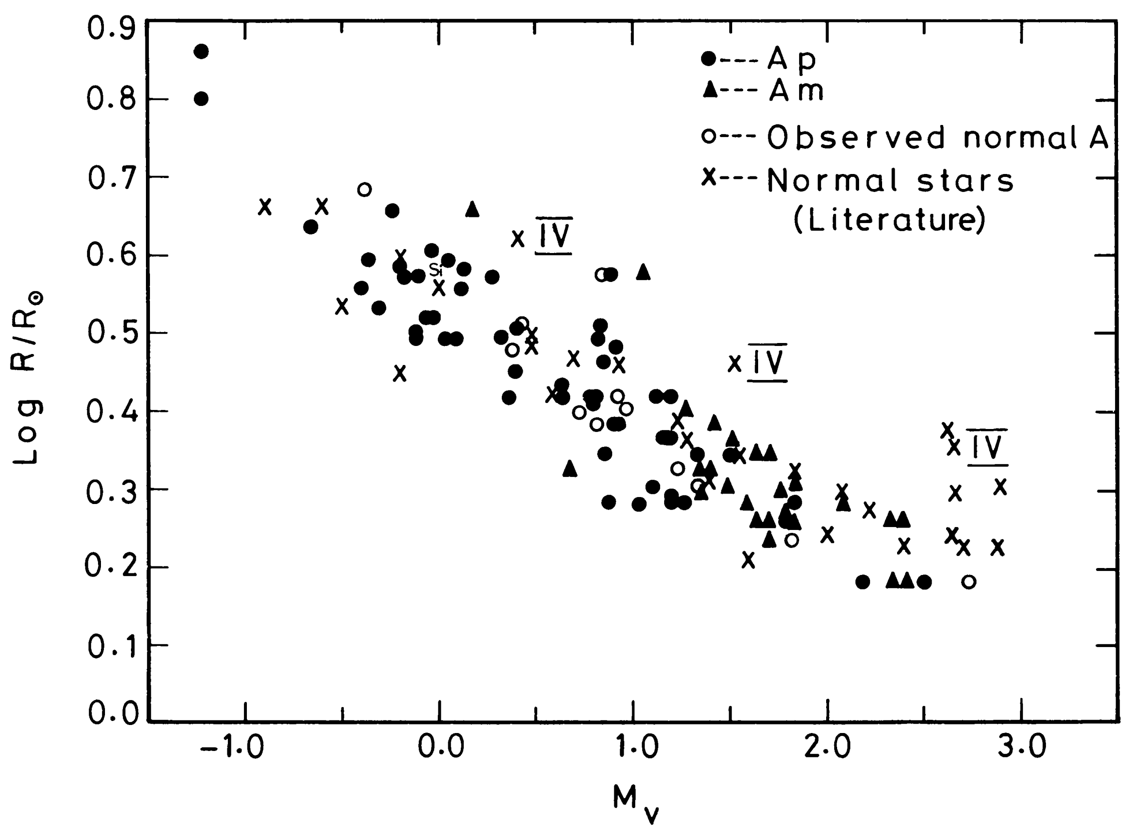

Fig. 2. The relationship between absolute magnitude (M_v) and radius ($\log R/R_{\odot}$) of normal A, Ap, and Am stars.

following the same general trend, those of the luminosity class IV being markedly away. However, on a closer look one may be inclined to say that the radii of the brighter Ap stars perhaps tend to be slightly larger than those of the Main-Sequence stars.

It has already been pointed out (Babu, 1977; Babu and Rautela, 1978; Muthsam and Weiss, 1978; Babu and Shylaja, 1981) that the radii in the wavelength range 4000–7800 Å are essentially uniform. Further, if there is any contribution due to the backwarming effect in this region, the above mentioned determinations of radii would be a little lower than the actual values. Thus when the backwarming effects (if at all present) are removed, the corresponding locations in Figure 2 may shift a trifle higher. As discussed sometime ago by Muthsam and Weiss (1978), the infrared fluxes are free from the backwarming effects and thus the radii determined on the basis of these fluxes are considered to be more realistic. They have determined the radius of α^2 CVn which has also been one of our program stars and a good agreement is seen in the values obtained by them as well as by us. Though this is a lone case, it nevertheless indicates that in Ap stars the backwarming effects may not be very serious in the wavelength region observed by us. However, for obvious reasons, the backwarming effect could be more significant in case of Am stars which at present appears to be well within the trend of the Main-Sequence stars in Figure 2.

The generally accepted idea that the Ap stars are slightly evolved and/or are in the process of leaving the Main Sequence is shown in Figure 3 of our recent paper (Babu and Shylaja, 1982) where the effective temperature is plotted against the bolometric magnitude. This implies a slight reduction in the effective temperatures compared to the Main Sequence along the corresponding evolutionary tracks, which is also manifested in Figure 1 of the above mentioned paper, where we see more number of Ap stars at lower temperatures relative to the temperature scale of the Main-Sequence stars. This obviously necessitates an increase in the size of the star, simply on the basis of their evolutionary aspects.

It is interesting to note in Table I that the non-Si stars have a general preference for radii smaller than $3.0\,R_\odot$. On the other hand, the choice for most Si stars seem to be

TABLE I

The number of Ap stars are shown for each peculiarity group in different ranges of radii

$R/R_\odot$ Pecularity	1.8–2.1	2.2–2.5	2.6–2.9	3.0–3.3	3.4–3.7	3.8–4.1	4.2–4.5
Si	3		2	4	2	3	
Si Cr		1	2	2			1
Hg Mn	1			2	3		
Cr	2		2				
Cr Eu	1	1					
Sr Cr Eu	2	1	1	2			1
Sr Cr		5	3			1	
Sr Eu				1			

on the higher side of $2.6 R_{\odot}$. This relationship, combined with that between the peculiarity group and temperature which also is similar (Hack and Struve, 1970; Osawa, 1965), further indicates the interdependence between their radii and evolution. Though Hubbard and Dearborn (1982) have suggested that the observed larger sizes of Ap stars could, at least partially, be due to the presence of global magnetic fields in them, in all probability the field (if sufficiently strong) could only be an additional contributing factor, the evolved nature being most likely the major cause.

3. Conclusions

Thus, we may conclude that as far as the radii are concerned, some of the Ap stars, being a little larger than the stars of the Main Sequence may not be much different from those of the slightly evolved normal A stars. This could be most likely due to the evolution of the brighter Ap stars. On the other hand, nothing much can be said about the radii of Am stars as long as their energy distribution curves are not corrected for the backwarming effects, excepting that they are presently merging with those of the Main-Sequance stars.

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