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PHOTOMETRIC PERIODS OF SOME OLD Si STARS

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ABSTRACT. Five stars with a small surface gravity have been monitored with Geneva photometry. Four vary with periods between 2.9 and 12.9 days, while the fifth may have a much longer period. These results are consistent with the view that Si stars do not lose their angular momentum on the main sequence, but that the conservation of it during evolution leads to a decrease of the rotational period.

1. INTRODUCTION

The question of whether, and to what extent, the rotational period of Ap stars may vary as a function of age is an old one. It was first examined by Wolff 1975, who examined field stars, using both their vsini and photometric period. She found a correlation between the period and the star's radius, but only for the non-SiAp stars, and interpreted it as due to magnetic deceleration acting on a timescale of a few 10^8 years. Hartoog 1977, on the basis of vsini observations, could not find evidence of any such braking for Ap stars in the Upper Scorpius association and in three clusters.

Abt 1979 and Wolff 1981, still on the basis of vsini data, claimed that Si stars lose angular momentum during their life on the main sequence, but the significance of their result was marginal. With the same kind of data, Klochkova & Kopylov 1984 reached the opposite conclusion, namely that any loss of angular momentum must have taken place before, not on, the main sequence stage.

Using the photometric periods in clusters and associations, North 1984a, b, 1987 and Borra et al. 1985 could find no evidence of magnetic braking on the main sequence, confirming the results of Klochkova & Kopylov 1984. However, a slight decrease of the period with age was noticed and confirmed by North 1985 with field Ap stars, but it can be easily explained by conservation of angular momentum as the star's radius increases as a result of evolution.

Because surface gravity is the most relevant physical parameter to study this correlation between period and age among field stars, North & Kroll 1989 determined it carefully for a large sample of CP2 stars, using $H\beta$ profiles. These surface gravities are much more reliable than those obtained from Geneva photometry, because the photometric indices are distorted by the peculiarities of the energy distribution. In fact, it is not demonstrated yet that the presence of a magnetic field and the probably pecul $T(\tau)$ relation due to the stratification of some elements in an Ap star's atmosphere do not alter the Balmer lines' profile in a significant way. We shall assume in the following that the effect of surface gravity is by far the greatest one, so that the log g values of North & Kroll indeed represent essentially the surface gravity, and hence the evolutionary state of the star within the main sequence.

Stars arriving at the end of their life on the main sequence are less numerous than the younger ones (because this stage is short), so we selected the few Ap stars with the smallest log g value from Table 1 of North & Kroll 1989 for a photometric monitoring.

RESULTS

Results have been obtained up to now for 5 ApSi stars which are listed in Table 1. Three of them have a very well defined period in the sense that there is no gross ambiguity due to sampling periodicities (spectral window). If any ambiguity remains, it is only between very close frequencies, due to the long time interval on which the measurements are spread.

The star HD 225119 has a low amplitude and its period is less certain: a period near 1.5 days may not be completely excluded. The star HD 174779 is a very difficult case: it has a small amplitude, and its period is either very close to one sidereal day or larger than 100 days. The latter possibility is slightly favoured by the periodograms, but more observations are needed. In any case, this star is surely most interesting: if its period is so long, then it will be one of the very few long-period ApSi stars. If its period is as short as one day, and if its surface gravity is indeed as small as claimed by North & Kroll 1989, then it may have been the most rapid rotator among all Ap stars when it was on the ZAMS.

In Table 1 are listed the surface gravities of North & Kroll 1989 (Table 1, column 6),corrected by the equation

$$\log g\ (\text{corrected}) = \log g\ (H\beta) + 0.14 \qquad (1)$$

which seems more realistic than their equation 16.

Fig. 1 shows the lightcurves of these stars. The results are summarized in a log P vs log g diagram (Fig. 2) where all He-weak, Si and SiCr stars with a known period and for which North & Kroll 1989 gave an estimate of log g are plotted.

CONCLUSION

Looking at Fig. 1, three conclusions are immediately apparent:

1. There are no very short periods among stars with a small surface gravity.

2. The trend for ApSi stars to have longer periods when they have smaller surface gravities, i.e. when they are more evolved, is confirmed. This is interesting, because the diagrams published so far were based on extremely approximate values of log g, based on Geneva photometry, while Fig. 2 is based on much more reliable data.

3. The observed trend can be readily explained by conservation of angular momentum during the evolution: the two solid lines in Fig. 2 represent the evolution of the period of 4 M© stars with an initial period of 0.5 and 4 days, assuming complete radial exchange of angular momentum (Endal & Sofia 1979). Therefore, our new data, although still sparse, confirm that no loss of angular momentum takes place during the main-sequence stage of ApSi and SiCr stars.

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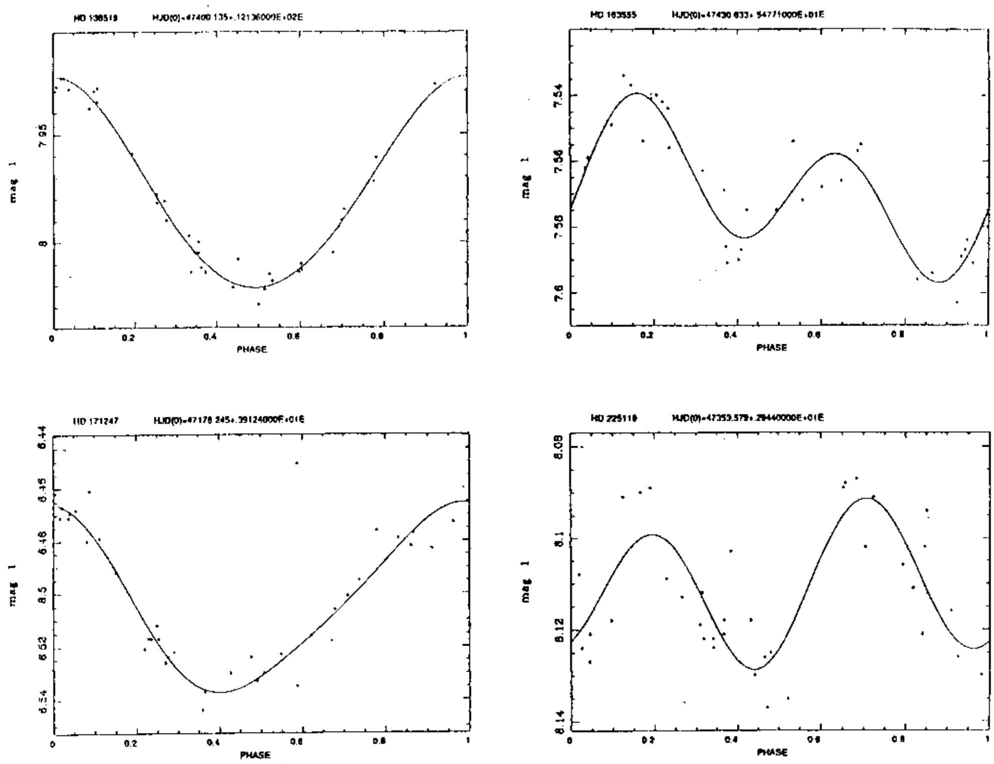
Table 1. New periods of evolved Si and SiCr Stars

HD	Type	m_V	corrected log g from NK89	Adopted photometric period (days)	Frequency peaks
138519	B8 Si	7.889	3.48 ± 0.05	12.136	ν=0.0824 ±n x 0.000272 with n=0,1,2,3...
163555	B8 Si	7.602	3.39 ± 0.10	5.4771	ν=0.18258 ±n x 0.000374
171247	B8 Si	6.414	3.56 ± 0.02	3.9124	no ambiguity
174779	A0 Si	6.641	3.50 ± 0.02	158 or 0.995?	more data needed
225119	B9 SiCr	8.190	3.59 ± 0.04	2.944 (1.47?)	ν=0.33967 ± 0.0095

Fig. 1 Lightcurves of the [U] Geneva passband of the four stars with a well-defined period.



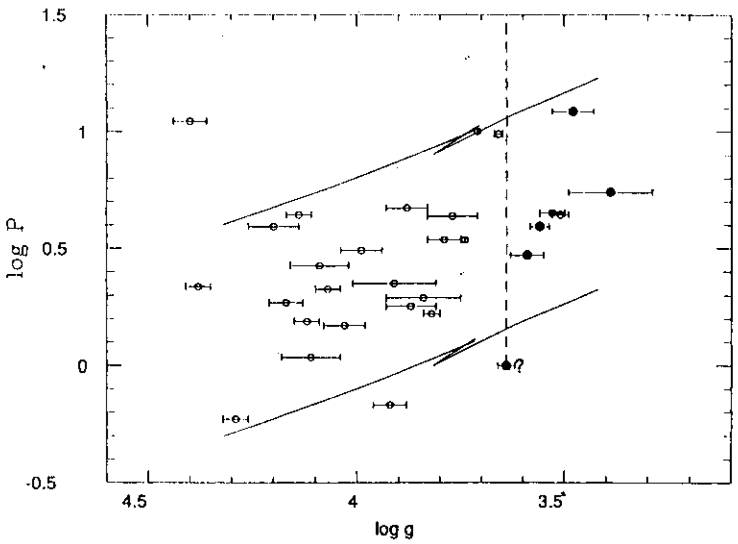


Fig. 2 Log P vs log g diagram for Si and SiCr stars with a published period and with log g measured by North & Kroll 1989. The full dots are the stars listed in Table 1. The curves show the evolution of the rotational period (from P=0.5 and 4 days on the ZAMS) with conservation of angular momentum (see text).