ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **125,** 497-499 (1997)

On the possible variability of the main sequence A stars θ Virginis and 109 Virginis*

Saul J. Adelman

Department of Physics, The Citadel, 171 Moultrie Street, Charleston, SC 29409, U.S.A.

Received December 17, 1996; accepted February 6, 1997

Abstract. Differential Strömgren *uvby* photometric observations from the Four College Automated Photoelectric Telescope are used to examine the possible variability of the spectrophotometric standards θ Vir and 109 Vir. No evidence is found for variability within a season of observation. Small year to year differences are most likely due to unaccounted for extinction changes.

Key words: stars: individual: θ Vir — stars: individual: 109 Vir — stars: variables: other

1. Introduction

If single main sequence band early A stars such as 109 Vir are low amplitude photometric variables (Taylor 1982, 1984), then our understanding of these stars needs to be revised. In an attempt to confirm or to set limits on such claims I use differential Strömgren *uvby* photometry obtained with 0.75-m Four College Automated Photoelectric Telescope (FCAPT) on Mt. Hopkins, AZ. Its first year of operation was Sept. 1990 - July 1991. The telescope measured the dark count and then in each filter the sky$-ch-c-v-c-v-c-v-c-ch-$sky where sky is a reading of the sky, *ch* that of the check star, *c* that of the comparison star, and *v* that of the variable star. From measuring two non-variable stars for each potentially variable star, one can derive an estimate of the accuracy of the photometry. Table 1 contains the yearly and total means and standard deviations while Tables 2 and 3 contain this information and the observations. No corrections have been made for neutral density filter differences among each group of variable, comparison, and check stars.

* Tables 2 and 3 will be available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

2. Observations

Taylor (1982, 1984) claimed that the bright A0 V star 109 Vir (= HR 5511 = HD 130109) which has been used as a spectrophotometric standard and as a primary four-color *uvby* standard (Crawford & Barnes 1970) is variable. However, numerous observations have been published of this star which indicate consistency, see, example, four-color observations by Olsen (1983, 1993) and Philip & Hayes (1984) and spectrophotometry in the later paper. These results might not be in conflict if 109 Vir is only occasionally variable with a few episodes a year. Such behavior has been seen in some rapid rotators.

To gain some insight on the stability of the FCAPT values, observations were also made of the nearby spectrophotometric standard θ Vir (= HR 4963 = HD 114330) which is a binary composed of an A1 IVs and an Am star. For 109 Vir the comparison and check stars were 108 Vir (= HR 5501 = HD 129956, spectral type B9.5 V) and 16 Lib (= HR 5570 = HD 132052, spectral type F0 V), respectively, while for θ Vir they were HR 5163 (= HD 119537, spectral type A1 V) and 66 Vir (= HR 5050 = HD 116568, spectral type F3-4 Vs), respectively. FCAPT differential Strömgren *uvby* observations were made during years 2 through 5. On some nights during years 4 and 5 observations of θ Vir alternated with those of 109 Vir for several hours.

Table 2 contains 231 observations of θ Vir with 16, 33, 84, and 98 in years 2, 3, 4, and 5, respectively. The data for years 4 and 5 are quite consistent. The worst offset is in the $c-ch$ values for u which is 0.004 mag or about 0.5 σ of the mean. The year 2 and 3 values show some minor differences, most notably slightly offset b $v-c$ and $ch-c$ and v $ch-c$ values, but these are less than 1 σ. The observations obtained in years 2 and 3 total only about one-half of that in either of the other two years so such differences may be partially due to statistics.

Another way to examine the possible variability of θ Vir is to study the data obtained on single nights. At the end of Table 2, I selected the data for those nights on which θ Vir was observed five or six times (these all

Table 1. Summary of yearly data

	u		v		b		y	
	$v-c$	$ch-c$	$v-c$	$ch-c$	$v-c$	$ch-c$	$v-c$	$ch-c$
θ Vir								
year 2								
average	0.315	0.587	0.177	0.268	0.221	0.518	0.238	0.750
std. dev.	0.006	0.006	0.009	0.007	0.011	0.008	0.012	0.009
year 3								
average	0.322	0.586	0.178	0.273	0.217	0.521	0.239	0.751
std. dev.	0.009	0.005	0.008	0.005	0.009	0.006	0.011	0.006
year 4								
average	0.325	0.582	0.180	0.271	0.210	0.524	0.237	0.755
std. dev.	0.009	0.007	0.005	0.004	0.005	0.004	0.005	0.004
year 5								
average	0.322	0.586	0.181	0.273	0.208	0.526	0.234	0.755
std. dev.	0.009	0.007	0.005	0.005	0.005	0.004	0.005	0.005
years 2-5								
average	0.322	0.584	0.180	0.272	0.211	0.524	0.236	0.754
std. dev.	0.009	0.007	0.006	0.005	0.007	0.005	0.007	0.006
109 Vir								
year 2								
average	−1.851	0.830	−1.925	0.739	−1.942	1.005	−1.947	1.191
std. dev.	0.004	0.004	0.006	0.006	0.006	0.005	0.005	0.006
year 3								
average	−1.849	0.840	−1.923	0.755	−1.940	1.017	−1.945	1.203
std. dev.	0.004	0.007	0.003	0.006	0.003	0.005	0.004	0.006
year 4								
average	−1.849	0.838	−1.933	0.759	−1.955	1.025	−1.960	1.212
std. dev	0.004	0.008	0.003	0.005	0.003	0.004	0.003	0.005
year 5								
average	−1.848	0.839	−1.932	0.762	−1.955	1.029	−1.961	1.214
std. dev.	0.004	0.005	0.003	0.004	0.003	0.004	0.004	0.004
years 2-5								
average	−1.849	0.838	−1.931	0.758	−1.952	1.024	−1.958	1.211
std. dev.	0.004	0.007	0.005	0.007	0.006	0.008	0.007	0.008

occurred in years 4 and 5). Within a given observing season or night θ Vir is not variable. But the slight offsets 0.003 mag in $v-c$ values for b and y seen in the averages of all values are also seen in the averages based only on the data taken on nights with 5 or more observations/night. Their origin is unknown, but could well be due to slight differences in the nightly extinction. The reduction used extinction coefficients which were consistent with several years of data. In summary within any given season of observation θ Vir is a constant star and the small differences between yearly means are not necessarily significant.

The 380 observations for 109 Vir are given in Table 3 with 28, 43, 143, and 166 in years 2, 3, 4, and 5, respectively. As for θ Vir, the data for years 4 and 5 are very consistent. The largest average offsets in $v-c$ are 0.001 mag, which implies constancy. Years 2 and 3 exhibit much larger offsets. Offsets in $v-c$ and $ch-c$ are of similar size which suggests we are seeing extinction produced differences. Further previous observers did not report such offsets. The much greater number of observations in years 4 and 5 also means that the results for these years are much more certain. At the end of Table 3, I selected the data for those nights on which 109 Vir was observed at least 5 times (these occur only in years 4 and 5). For each the averages for these nights are similar to those for the year. There is not a night which exhibits any variability

episode in agreement with Philip & Hayes (1984). Thus the apparent variability episodes for 109 Vir at best are rarer than originally claimed.

3. Discussion

The question of stellar stability is extremely important. To do further reduce the limits on variability requires more precise and accurate photometry with a large number of observations comparable with this paper's. An observer using CCDs to search for variables and their periods among cluster stars might be able to provide such data.

Acknowledgements. This work was supported in part by NSF grant AST-9115114 to The Citadel and in part by grants from The Citadel Development Foundation. I appreciate the continuing efforts of Louis J. Boyd and Robert J. Dukes, Jr., to keep the FCAPT operating properly as well as the useful comments of the referee Dr. E.H. Olsen.

References

Crawford D.L., Barnes J.V., 1970, AJ 75, 978
Olsen E.H., 1983, A&AS 54, 55
Olsen E.H., 1993, A&AS 102, 89
Philip A.G.D., Hayes D.S., 1984, PASP 96, 546
Taylor B.J., 1982, PASP 94, 663
Taylor B.J., 1984, ApJS 54, 259