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The Photometric Variability of K Giants

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ABSTRACT. We have photometrically monitored 49 of the more than 200 K giants in the *Yale Catalog of Bright Stars* which are named or suspected variable stars. Only two (HR 3275 and HR 5219) are clearly variable; a few more program stars and K- and M-giant comparison stars are marginally variable. Most of these appear to be RS Canum Venaticorum or SR variables.

1. INTRODUCTION

Surveys of the photometric variability of red giants, going back to Stebbins and Huffer (1930), have indicated that K giants are *not* usually variable; variability sets in at about M1 III, and its incidence, amplitude, and time scale *tend* to increase with decreasing temperature. Nevertheless, there are 16 named and 215 suspected variables among the approximately 1600 (!) K giants in the *Yale Catalog of Bright Stars* (YCBS); Hoffleit and Jaschek 1982). The purpose of this paper is to investigate the status of some of the suspected variables and, if they are actually variable, to determine the nature and cause.

Of the 16 named K-giant variables in the YCBS, at least five and probably more are actually not variable, five are probably RS Canum Venaticorum stars, and two are VV Cephei stars. It should also be noted that K supergiants (and to a lesser extent, K bright giants) show a larger incidence of variability or suspected variability, as noted, for instance, by Maeder (1980).

An interesting case is HR 9008 (τ Cassiopeiae), listed as VAR? in the YCBS, with a possible amplitude of 0.3. Some observers have claimed recent variability, while others (Percy 1985; Halbedel 1989) have seen none. Halbedel (1993) suspects a recent (1991, 1992) slight brightening by 0.03 in V, whereas recent photoelectric observations by the American Association of Variable Star Observers (H. J. Landis, private communication) show, if anything, a slight fading by 0.01 in V.

Why be concerned whether K giants are variable? First of all, to "tidy up" the YCBS, and our general information on star variability. Most of all, however, to discover whether there might be a class of variable stars (nonradial pulsators, for instance?), which might have escaped detection until now. The early F-type "variables without a cause" (Krisciunas 1993), including 9 Aurigae, HD 96008, γ Doradus, and HD 164615, are a case in point.

2. OBSERVATIONS

The 49 program stars were monitored automatically with a 25-cm reflector through the APT (Automatic Photoelectric Telescope) Service of the Fairborn Observatory, on Mt. Hopkins in Arizona. Michael Seeds, the Principal Astronomer, manages the observation, data reduction, and quality control (Seeds 1989). The APT imposes some restrictions on the declination of the stars (generally north of the equator), on the presence of other bright stars near them, and on the availability of suitable comparison stars. The program stars eventually selected are listed in Table 1, along with the comparison and check stars. The program stars are taken from among the suspected K-giant variables in the YCBS, and should be an unbiased sample. Note that many of the comparison and check stars are also K giants. None of them were known (as of the fourth edition of the YCBS) to be suspected variables.

The stars were monitored for three months each during 1992. If the time scale of the variability was much longer than this, it would not have been detected.

3. RESULTS

The results of the survey are summarized in Table 1 which gives, for the program, check, and comparison stars, the name, V, $(B-V)$, and spectral type. For the program and check stars, the mean ΔV relative to the comparison star, and its standard deviation σ, are also given. Finally, an assessment of the variability is given: constant if $\sigma \leqslant 0.01$, constant (?) if $0.01 < \sigma \leqslant 0.015$, variable (?) if $0.015 < \sigma \leqslant 0.02$, and variable if $\sigma > 0.02$. Notes on individual stars are given below.

4. NOTES ON INDIVIDUAL STARS

HR 393/385/416. One of these may be slightly variable, but this conclusion depends largely on one point.

HR 808. May be variable by up to $\Delta V = 0.07$.

HR 940. The range is small ($\Delta V \sim 0.03$) but probably significant; the time scale appears to be > 100 days (Fig. 1). Given the M0 III spectral type, the slight variability is not surprising.

HR 1411. The star appeared, from several measurements, to have faded by $\Delta V \sim 0.1$ around JD 2448910 (Fig. 2). Previous measurements of this Hyades member show very little scatter.

HR 2097. May be variable with $\Delta V \sim 0.04$ and a time scale of a few days.

HR 2854. May be variable with $\Delta V \sim 0.04$ and a time scale > 100 days. The star is a 389-day spectroscopic binary.

HR 3275. The range is $\Delta V \sim \Delta B \sim 0.05$, and the time scale is 25–30 days (Fig. 3).

TABLE 1
Results of a Survey of the Photometric Variability of a Sample of Suspected Variable K Giants

Program Star							Check Star							Comparison Star				
HR	V	B-V	SpT	ΔV	σ	R	HR/HD	V	B-V	SpT	ΔV	σ	R	HR/HD	V	B-V	SpT	R
393	6.49	+1.08	gK0	+0.599	0.028:	v?	416	6.41	+1.24	K0 IV	+0.545	0.017:	v?	385	5.87	+0.64	G8 III +	v?
828	5.82	+1.20	K1 III	-0.555	0.022	v?	869	5.63	+0.43	F6 V	-0.796	0.030	v?	808	6.46	+1.07	K2 III	v?
843	4.53	+1.56	K7 III	-1.702	0.010	c	882	4.93	+1.23	K2 III	-1.323	0.006	c	819	6.25	+0.93	G8 III	c
951	4.35	+1.03	K2 III	-0.749	0.005	c	940	6.27	+1.58	M0 III	+1.174	0.011	c?	1015	5.09	+1.24	K3 III	c
1407	4.97	+1.13	K2 III	+1.094	0.066	c?	1396	4.69	+0.98	G7 III	+0.827	0.044	c?	1411	3.84	+0.95	K0 III	v
1709	5.50	+1.37	gK4	-0.382	0.004	c?	1837	6.21	+1.27	K2 III	+0.315	0.009	c?	1691	5.89	+0.66	F5	c?
1830	5.79	+1.15	k1 III	+0.726	0.009	c?	1834	4.71	+1.57	K5 III	-0.364	0.011	c?	1787	5.08	+0.96	G9 III-IV	c?
2037	4.78	+1.38	K1.5 II	-1.559	0.004	c	2057	6.000	+1.34	K0 III	-0.327	0.008	c	2051	6.31	+1.29	K0	c
2113	4.53	+1.22	K2 III	-1.677	0.015	c?	2007	5.97	+0.64	G4 V	-0.232	0.013	c?	2097	6.22	+1.14	K0	v?
2480	5.44	+1.45	K4 III	-0.511	0.011	c	2697	4.41	+1.26	K2 III	-1.555	0.009	c	2643	5.93	+0.60	G4 V	c
2561	6.05	+1.49	K3 III	+1.672	0.009	c	2477	5.35	+0.96	K0 III	+0.993	0.008	c	2560	4.35	+0.85	G5 III-IV	c
2864	4.54	+1.28	K1 III	-0.832	0.010	c	2854	4.32	+1.43	K3 III	-1.027	0.019	v?	2820	5.30	+0.10	A5 IV	c
2983	5.31	+1.54	K4-5 III	-0.927	0.010	c	3021	6.18	---	G2 III +	-0.037	0.005	c	2978	6.21	+0.93	K0 III	c
3141	4.68	+1.49	K4 III	-1.713	0.009	c	3122	4.93	+1.21	K2 III	-1.461	0.009	c	3172	6.41	+1.05	K0	c
3275	4.25	+1.55	K4.5 III	-1.779	0.014	v	3309	6.32	+0.62	G5 V	+0.298	0.013	c?	3287	6.02	+1.59	K5 III	c?
3550	5.41	+1.46	gK5	-1.025	0.015	c?	3599	5.85	+1.11	gK3	-0.636	0.012	c?	3635	6.48	---	F2 V	c?
3660	5.27	+1.56	K5 III	-1.056	0.014	c?	3747	6.45	---	F3 V	+0.163	0.028	v?	3506	6.25	---	F5 IV-V	c?
3827	5.00	+1.05	K1 III	-0.708	0.012	c	3834	4.68	+1.32	K3 III	-1.030	0.009	c	3755	5.71	+1.04	K0 III	c
3845	3.91	+1.32	K2.5 III	-2.426	0.045:	c?	3758	6.27	+0.27	F0 V	-0.069	0.012	c	3907	6.35	+0.94	G9 III	c
4178	5.12	+1.20	K2 III	-0.627	0.011	c	4181	5.00	+1.38	K3 III	-0.734	0.010	c	4176	5.75	+1.30	gK3	c
4518	3.71	+1.18	k@ III	-2.403	0.008	c	4430	6.35	+1.27	K2 III	+0.248	0.032	v	4480	6.10	+0.38	F5 III	c
4610	6.13	+1.17	K2 III	-0.609	0.014	v?	4569	6.22	+0.96	G8 III	-0.516	0.008	c	4575	6.76	---	K0 III	c
4668	5.00	+1.14	K0.5 III	-0.960	0.008	c	4593	5.59	+1.01	K0 III	-0.361	0.013	c?	4581	5.96	+1.15	K1 III	c
4693	5.54	+1.09	K2 III-IV	+0.608	0.007	c	4737	4.36	+1.13	K2 III	-0.581	0.007	c	4733	4.95	+0.27	F0p	c
4925	5.99	+1.12	K2 III	-0.467	0.009	c	4937	6.59	+0.29	F0 V	+0.135	0.013	c?	4896	6.44	+1.10	K0	c
5159	5.36	+1.11	K2 III	-1.158	0.018	c?	5086	6.17	+1.47	K5	-0.323	0.011	c	5087	6.51	+0.96	K0	c
5200	4.07	+1.52	K5 III	-1.667	0.011	c	5243	6.16	+0.50	F6 V	+0.462	0.011	c	5225	5.70	+0.84	G5 III	c
5219	4.74	+1.66	K5 III	-1.250	0.016	v	5195	5.62	+1.01	K0 III	-0.376	0.011	c	5161	5.98	+0.85	G5 III	c
5247	5.01	+1.42	K3 III	-0.906	0.005	c	5263	6.23	+0.17	A7 III	+0.315	0.009	c	5229	5.90	+0.20	A7 V	c
5370	4.86	+1.23	K3 III	-2.075	0.009	c	5352	5.80	+1.71	M3III	-1.082	0.030	v	126269	6.90	+0.65	G0 V +	c
5448	6.03	+1.38	gK5	-0.198	0.008	c	5402	6.27	+1.23	gK2	+0.068	0.009	c	5416	6.10	---	K0 III	c
5709	5.51	+1.02	K0 III	-0.490	0.014	c?	5676	5.26	+0.03	A2 V	-0.719	0.010	c	5674	5.99	+1.52	K5	c
5710	5.35	+1.19	K3 III	-0.511	0.007	c	5772	5.51	+1.09	K0 III	-0.366	0.009	c	5690	5.89	+1.31	K5 III	c
5744	3.29	+1.16	K2 III	-2.635	0.010	c	5768	6.38	---	K5	+0.413	0.010	c	5755	5.90	+1.44	K5 III	c
5841	6.45	+1.09	K1 III	-0.454	0.009	c	5744	3.29	+1.16	K2 III	-3.612	0.012	c?	138367	6.87	+0.49	F6 IV-V	c
5899	4.76	+1.54	K4-5 III	-0.696	0.010	c	5966	5.12	+0.99	G8 III	-0.342	0.015	c?	5924	5.44	+1.59	M0 III	c
6018	4.76	+1.01	K0 III-IV	-1.569	0.011	c?	6046	5.63	+1.34	K3 III	-0.672	0.007	c	6043	6.29	+1.20	K2 III	c
6228	5.15	+1.53	K5 III	-1.752	0.009	c	151090	6.58	+0.88	K0 V	-0.352	0.015	v?	151879	6.91	+0.91	G5	c
6299	3.20	+1.15	K2 III	-3.197	0.013	v?	6390	6.33	+1.04	K0 III	-0.042	0.017	v?	6358	6.37	+1.45	K5 III	v?
6318	4.82	+1.48	K4 III	-0.413	0.011	c?	6372	6.36	+0.69	G5-8 IV-V	+1.125	0.017	v?	6280	5.25	+1.08	K2 III	c?
6363	6.09	+1.09	K1 III	-0.517:	0.015:	?	6286	6.00	+1.32	K2 III	-0.634:	0.013:	?	6306	6.62	---	M2 III	?
6695	3.86	+1.35	K1 II	-2.155	0.032	v?	6711	6.00	+0.94	gG5	+0.024	0.010	c?	6673	6.04	+1.33	gK4	c?
6895	3.84	+1.18	K2.5 III	-1.090	0.015	c?	6882	5.41	+1.60	M0 III	+0.481	0.013	c?	6868	4.95	+1.59	M1 III	v?
7798	5.58	+1.08	K0 III	-0.867	0.010	c?	7733	6.14	+1.50	K4 III	-0.321	0.007	c	7841	6.41	+1.13	K2 III	c
7956	4.92	+1.32	K3 III	-0.598	0.007	c	8005	5.47	+1.52	gK5	-0.049	0.008	c	7921	5.51	+0.88	G8 II	c
8485	4.49	+1.39	K3 III	-0.374	0.012	c?	8536	6.22	+0.49	F5 IV	+2.002	0.118	?	8498	4.13	+1.46	K3 II-III	c?
8930	5.22	+1.02	K0 III	-0.833	0.014	c?	8950	6.18	+1.58	K5	+0.126	0.016	c?	8927	6.05	+0.99	G9 III	v?
8943	4.98	+1.38	K4 III	-0.648	0.009	c	8955	6.35	+0.46	F6 V	+0.700	0.009:	c?	8948	5.63	+1.03	gK0	c
8986	6.57	---	gK5	-0.164	0.020	c?	8941	6.24	+0.98	G8 II	-0.338	0.017	c?	8964	6.44	---	G5	v?

TABLE 2
Probable and Possible Variable Stars

Star(HR)	Spt	Type	Range(V)	Time Scale	Status
940	M0 III	SR?	0.03	>100 days	probable
1411	K0 III	?	0.1	fading	"
3275	K4.5 III	RS CVn?	0.05	25-30 days	"
4430	K2 III	ell	0.09	40 days	EE uMa
5219	K5 III	RS CVn?	0.05	25 days	AW CVn
5352	M3 III	SR	0.15	50,>100 days	probable
5924	M0 III	SR	0.07	20 days?	"
6868	M1 III	SR?	0.05	≥ 40 days	"
808	K2 III	?	≤0.07	?	possible
2097	K0	?	0.04	few days	"
2854	K3 III	?	0.04	> 100 days	"
3747	F3 V	δ Sct?	0.1	?	"
4610	K2 III		0.04	weeks?	"
6280	K2 III		0.05	30 days?	"

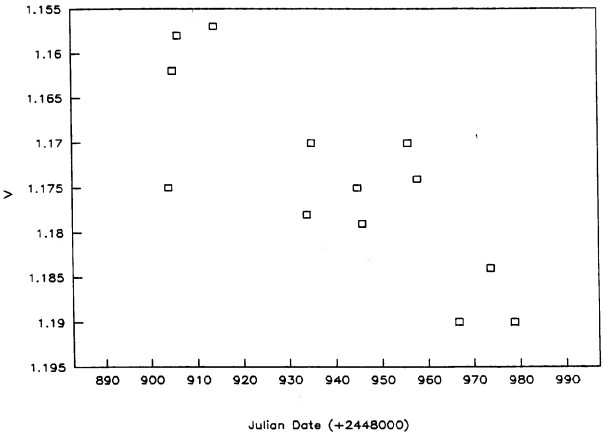

FIG. 1—The *V* light curve of HR 940 relative to HR 1015; the *B* light curve is similar.

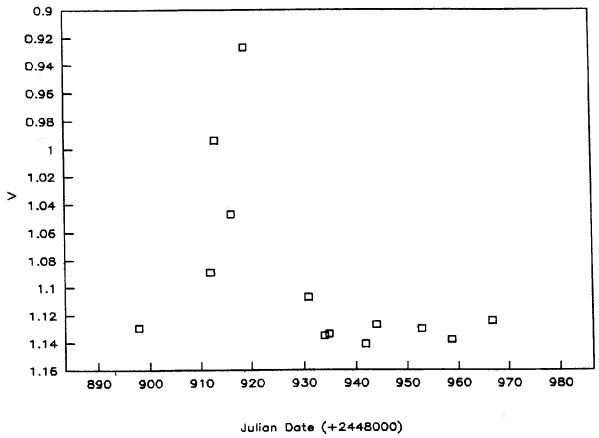

FIG. 2—The inverse V light curve of HR 1411; (since the variations 1407–1411 and 1396–1411 are similar, we conclude that 1411 is the variable). The B light curve is similar.

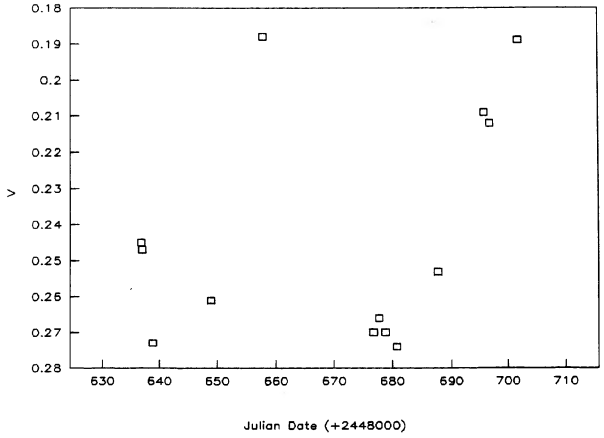

FIG. 4—The V light curve of HR 4430 (EE UMa) relative to HR 4480; the B light curve has a slightly larger range. The star is a chromospherically active ellipsoidal variable.

NSV 4030. The range is $\Delta V \leqslant 0.05$ according to the *New Catalog of Suspected Variable Stars* (Kholopov 1982). The star shows Ca II emission according to the catalog of Glebocki et al. (1980).

HR 3747. The range is $\Delta V \sim \Delta B \sim 0.1$; there is no obvious time scale. Given the F3 V spectral type, this could be a δ Scuti star.

HR 3845/3907/3758. There are two discordant observations on one night, one incomplete and the other with a large internal error.

HR 4430. This star (EE Ursae Majoris) is now known to be a chromospherically active ellipsoidal variable with a period of 74.861 days. The photometric period varies around 38–39 days, and the range V is about 0.1 (Strassmeier et al. 1989). Our measurements (Fig. 4) show $\Delta V \sim 0.09$ and $\Delta B \sim 0.11$, on a time scale of about 40 days.

HR 4610. The variability is marginal ($\Delta V \sim \Delta B \sim 0.04$) and the time scale may be a few weeks. The star's designation CSV 102691 (*Catalog of Suspected Variables*, Kukarkin et al. 1951) probably refers to the fainter visual companion.

HR 4937. The variability is marginal. Casas and Gomez-Forrellad (1989) used it as a comparison star, and did not mention any variability. Given the F0 V spectral type, it could be δ Scuti star.

HR 5159. The variability is marginal, and depends largely on one point. The star's designation NSV 6401 may refer to the 8th magnitude G-type visual companion.

HR 5219. This star (AW CVn) is classified as an SR: type with $\Delta V = 0.1$. Since the star has Ca II emission (Glebocki et al. 1980), it is more likely an RS CVn star. Our measurements (Fig. 5) show a range $\Delta V \sim \Delta B \sim 0.05$ and a time scale of 25 days.

HR 5352. The range is $\Delta V \sim \Delta B \sim 0.15$ (Fig. 6). Two or more time scales (50 and > 100 days) may be present, as in many small-amplitude red variables. Given the M3

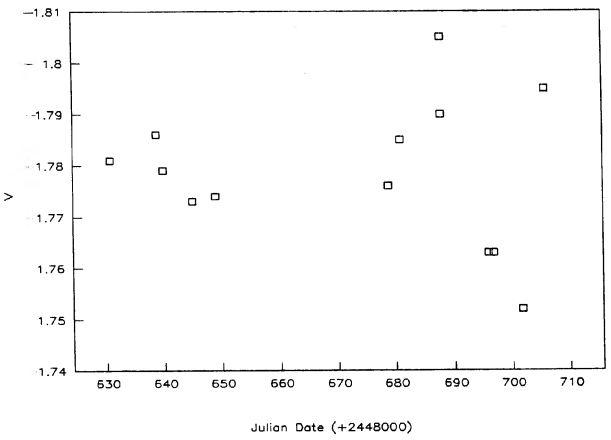

FIG. 3—The V light curve of HR 3275 relative to HR 3287; the B light curve is similar.

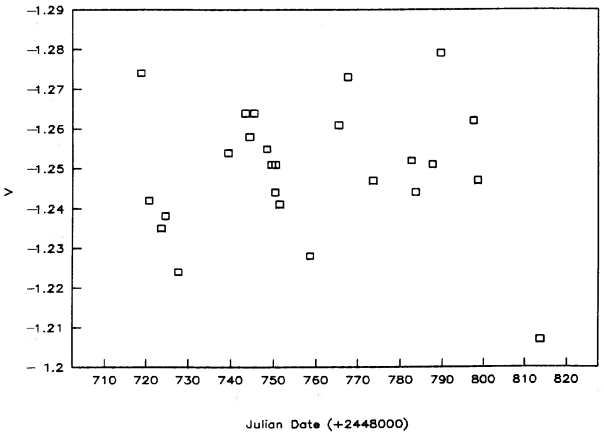

FIG. 5—The V light curve of HR 5219 relative to HR 5161; the B light curve is similar. The time scale appears to be 25 days.

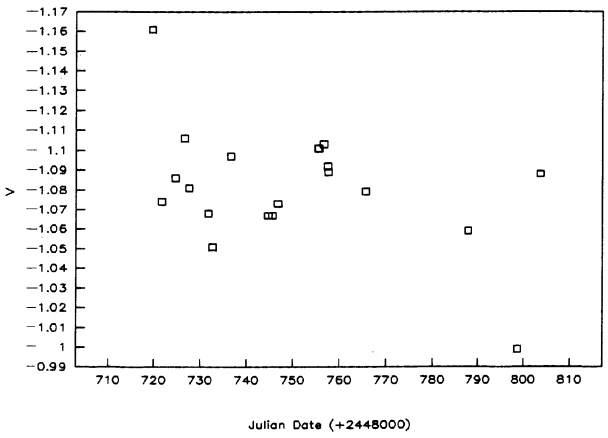

FIG. 6—The *V* light curve of HR 5352 relative to HD 126269; the *B* light curve is similar. Spectral-type M3 III; evidently an SR variable.

III spectral type, the variability is not unexpected.

HR 5709. One discordant (and incomplete) measurement on JD 2448771.

HR 5924. Evidently an SR variable with $\Delta V \sim \Delta B \sim 0.07$ and a time scale of 20 (?) days (Fig. 7). The spectral type is M0 III. Percy and Fleming (1992) found the star constant.

HD 151090. The variability is marginal, and the time scale, if any, is 20–30 days.

HR 6280. The range is $\Delta V \sim \Delta B \sim 0.05$, and the time scale, if any, is about 30 days (Fig. 8).

HR 6299/6358/6390. One or more of these may be slightly variable.

HR 6372. Marginally variable.

HR 6695. The variability is marginal, and depends largely on one point. This is actually a K1 II "hybrid giant."

HR 6868. There are only 11 points, but they seem to

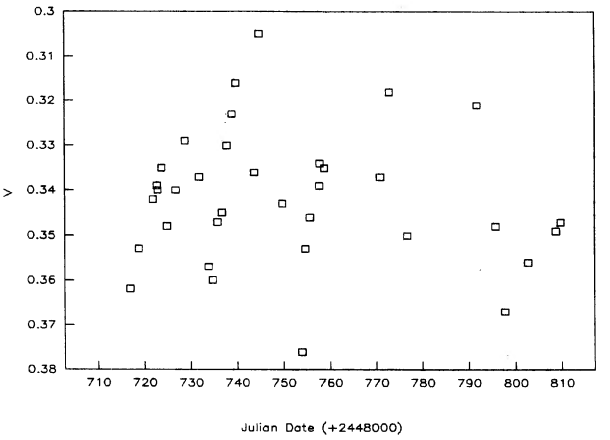

FIG. 7—The *V* light curve of HR 5924 relative to HR 5966; the *B* light curve is similar. Spectral-type M0 III; evidently an SR variable.

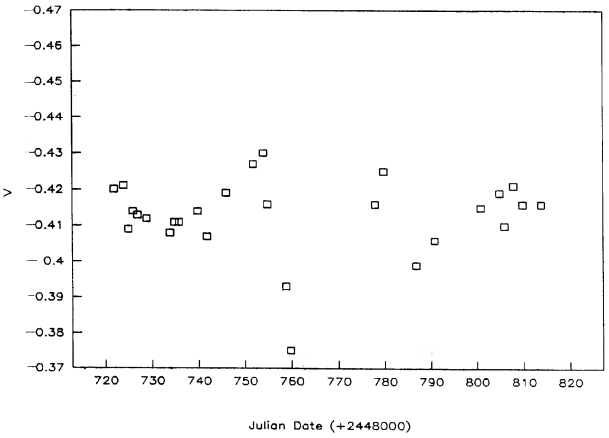

FIG. 8—The inverse *V* light curve of HR 6280; (since the variations in 6318–6280 and 6372–6280 are similar, we conclude that 6280 is the variable). The variability is small, but the measurements all have small internal errors.

indicate a variability of $\Delta V \sim \Delta B \sim 0.05$, and a time scale $\geqslant$40 days (Fig. 9).

HR 8536. There are several measurements which are discordant by up to $\Delta V \sim 0.4$ (!), but they have large internal errors.

HR 8964. The variability is marginal, with $\Delta V \sim \Delta B \sim 0.05$, and a time scale, if any, of about a month.

5. DISCUSSION AND CONCLUSIONS

We have monitored a significant fraction of all the K-giant known or suspected variables in the *Yale Catalog of Bright Stars*. Almost all of them were constant (over three months or less). A few (Table 2) were marginally variable. Several comparison stars (Table 2) were marginally or definitely variable. These were either SR variables (M III type) or RS CVn variables (K III type). We cannot rule out the possibility that a *few* K giants are SR

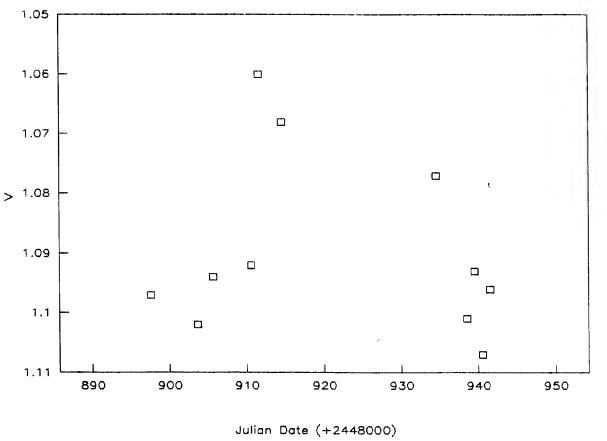

FIG. 9—The *V* light curve of HR 6868 relative to HR 6895; the *B* light curve is similar.

variables with $\Delta V \leqslant 0.05$, but the evidence is weak, and the number of such stars is small.

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