A PHOTOELECTRIC STUDY OF MAGNETIC VARIABLE STARS*

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Abstract

Eleven magnetic stars for which brightness variation had not been reported were selected from the Babcock Catalog and studied photoelectrically in visual and blue light during 1967 and 1968. Two were found to vary periodically. Periods and initial epochs determined are: HD 30466, maximum blue light at HJD 2,439,870.63 + $1^d.39E$, and HD 184905, maximum visual light at HJD 2,440,017.0 + $1^d.855E$. Light curves are given in B and V for HD 30466, and in U, B, and V for HD 184905. Two of the magnetic stars, 45 Leonis and β Coronae Borealis appear to vary but data are insufficient to establish period or amplitude of variation. Seven selected stars appear to be constant. Four comparison stars appear to vary by $^m.02$ or more in either blue or visual light or in both. They are HD 71150, HD 77694, 44 Leonis, and HD 135576. HD 25354, observed by Rakos, was also included in this study in yellow light only. The improved period is $3^d.9007 \pm {}^d.0001$. A method for determining period from a small number of observations is given.

Introduction. The photometric study of magnetic variable stars is the first major project undertaken at the King College Observatory. Magnetic variable stars, selected from the catalog published by H. W. Babcock (1958) were studied to detect brightness variation and periodicity.

Four other observers have reported on such searches. Pioneer work was done by Provin (1953 a, b, c) who observed twenty peculiar A stars before the Babcock Catalog was published. He found periodic light variation for seven of the stars with amplitudes of $^m.02$ or greater, possible variation for eight, and no variation for five. Jarzebowski (1960 a, b, c, d; 1961) reported variation for seven magnetic stars or spectrum variables. Rakos (1962 a, b; 1963 a, b) found periodic variations of $^m.02$ or more for fourteen magnetic stars or spectrum variables, three of which had been studied previously by Jarzebowski. Neither of these two observers report any of the stars to be constant, and one cannot be certain whether this is because they found none, or because they failed to report absence of variation. In a recent publication, Stepień (1968) reported careful UBV photometry on twenty-two magnetic and spectrum variables. Nine of these had been previously re-

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ported variable by Jarzebowski or Rakos. He found two to be constant and twenty to be variable; six with amplitudes less than $^{m}.015$ in each of the three colours. So small a variation would be on the limit of detectability for this investigation.

Abt and Golson (1962) made a statistical study of all the stars in Table I of the Babcock Catalog. They found large standard deviations from the average brightness of many of the stars and concluded that virtually all are variable. Stepień (1968) on the basis of his observations agreed with their conclusions but found no correlation between their σ values and his own.

A complete bibliography of photoelectric work on individual magnetic stars and spectrum variables was given by Hardie (1965).

Description of the Project. Stars from the Babcock Catalog (1958), most of which had not been subjected to intensive photoelectric study, were selected and an attempt was made to determine whether or not they vary in light. If so, the period was sought. Most of the stars were studied in two colours, blue and visual. One star, HD 184905, Babcock 70, was also studied in the ultraviolet. Observations and evaluations for eleven such stars are reported. Three stars of known period and light variation were added to the program so that their periods could be improved and so that observing techniques could be carefully evaluated. Observations for two of these are not reported in this paper but have been combined with work of other observers and will appear in separate papers. The statistical photometric study of Abt and Golson (1962) was used as a guide for selection of some of the stars. Our observations indicate that the σ values in that paper are too large and that it is not reliable as such a guide.

Most observations were made at the Kitt Peak National Observatory with the number three 16-inch telescope equipped with a refrigerated 1P21 photomultiplier tube and standard UBV filters, during extended observing periods in May and June 1967, December and January 1967–68, and June 1968. Some supporting observations were made with the King College Observatory $12\frac{1}{2}$-inch reflecting telescope using a refrigerated 1P21 photomultiplier tube and standard UBV filters.

When it became obvious that a large fraction of the selected stars was not variable, an effort was made to analyze the constancy.

Techniques of Data Analysis. All difference observations are in the standard UBV system unless otherwise noted. All observations were made when the stars were very close to the meridian. Since variations were smaller than had been anticipated, frequent and careful calibrations of the integrator were required. Observations were generally made by using two comparison

stars very close to the suspected variable. A single observation of a star consisted of a deflection produced by light from the star, a deflection by the sky, and another deflection by the star. The three stars were usually observed in turn for at least four complete cycles of observation of all three stars. This process required about thirty minutes in each colour. After extinction corrections had been applied, magnitude differences from all consecutive star observations were calculated and averaged. The standard deviation of magnitude difference observations from the average value is given in Table IV in the column designated "S.D." These appear as error bars on the curves to indicate the quality of the observations. Thus magnitude differences given in this paper are normally the average of four individually observed differences. The number of observations comprising the point appears in the column designated "N."

The standard deviation of nightly differences from the average difference for the entire run was determined. This was done for the magnitude difference of the suspected variable and one of the comparison stars, and for the difference in magnitude of the two comparison stars over the observing period to decide whether they are variable or constant. If stellar variation was detected, the term mean amplitude refers to the magnitude variation of the smoothed light curve. Observations for stars which showed variation appear in Table IV.

Method for Determining Period of Variation. A method for discovering period from a small number of observations was devised with the help of Dr. William H. Somerville of the King College mathematics department. It is similar to a method used by Lafler and Kinman (1965) to deal with RR Lyrae stars.

All observations are reduced to a single phase using a trial period with digital computer. The program then joins adjacent points by straight lines and the total length of the curve is computed for the period. The computer does this for any number of trial periods at regular intervals and prints out length of curve as a function of trial period. The shortest curve gives the best period for the data.

Results

A. Magnetic Stars Discovered to be Variable:

HD 30466 = BD 29°742 = Babcock 17. HD 30466 was observed on eleven nights at Kitt Peak during December and January 1967–68. Comparison stars were HD 29537 and HD 30379. It was determined to have a mean amplitude of $^{m}.041$ in the blue. A period could not have been determined from visual observations. The probable period is $1^{d}.39 \pm .2$, and light curves

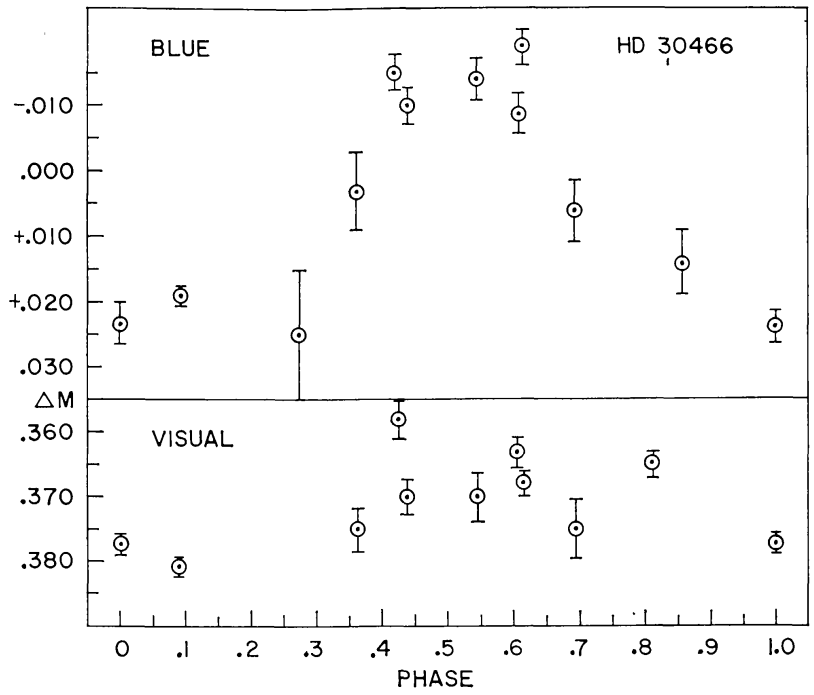

FIG. 1—Light curves in B and V for magnetic variable star HD 30466. Differences are HD 30466 − HD 30379. Probable period is 1.39 ± ᵈ.2.

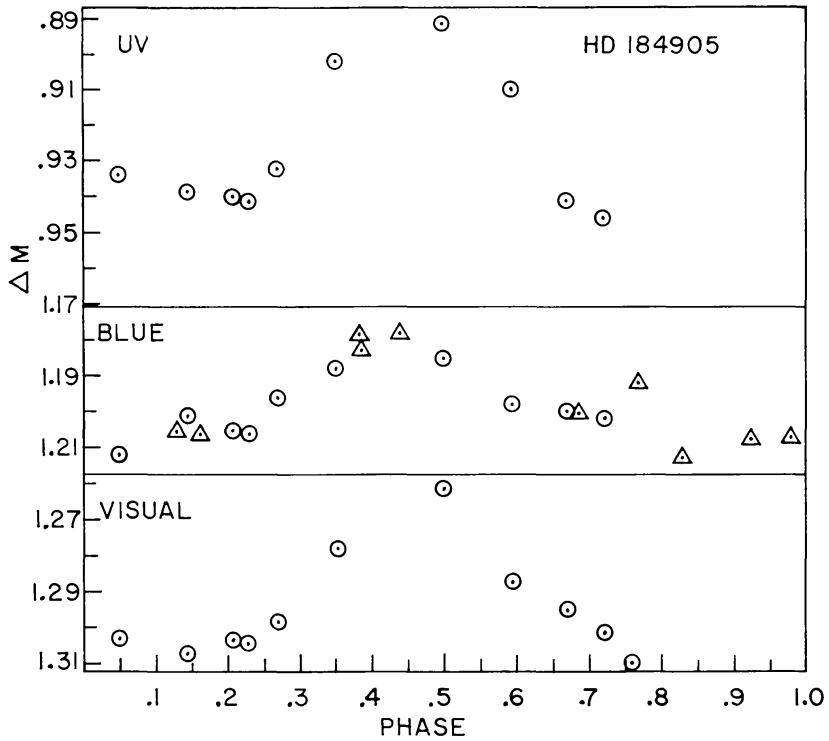

FIG. 2—U, B, and V light curves for HD 184905. ΔM signifies the difference HD 184905 − HD 184875. Triangles on the Blue curve represent observations from summer 1967 which were not on the UBV system. Values were adjusted to conform with later values (circles) which are on the standard UBV system.

in two colours are shown in Figure 1. These data would not rule out periods of about $3^d.5$ or $7^d.1$; however, later observations make it possible to eliminate the 7.1 day period. Time of initial epoch was the time of maximum blue light: HJD 2,439,870.63 $\pm$ $^d.05$. Observation of this star is being continued in three colours.

HD 184905 = BD 43°3290 = Babcock 70. HD 184905 was observed for nine nights in May and June 1967 in the blue only, and for ten nights in three colours in June 1968 at Kitt Peak. Comparison stars were HD 184875 and HD 185872. It was found to have mean amplitudes of $^m.069$ in U, $^m.0241$ in B, and $^m.0491$ in V. It was also observed at King College. The period is 1.855 $\pm$ .001 days. Light curves in three colours are shown in Figure 2. The initial epoch for maximum light in visual is HJD 2,440,017.0 $\pm$ .1 days. Observation is being continued.

B. Magnetic Star Previously Known to be Variable:

HD 25354 = BD 37°866 = Babcock 14. HD 25354 was observed to be variable by Rakos (1962b). His ephemeris for minimum light is 2,437,315.14 + 3.9001E, and the mean amplitude in visual light was $^m.032$. In this investigation, observations were made in visual light only, for ten nights at Kitt Peak in the winter of 1967–68. Magnitude differences in Table IV for this star are given on the instrumental rather than the standard UBV system. The mean variation was found to be $^m.033$. The improved period is 3.9007

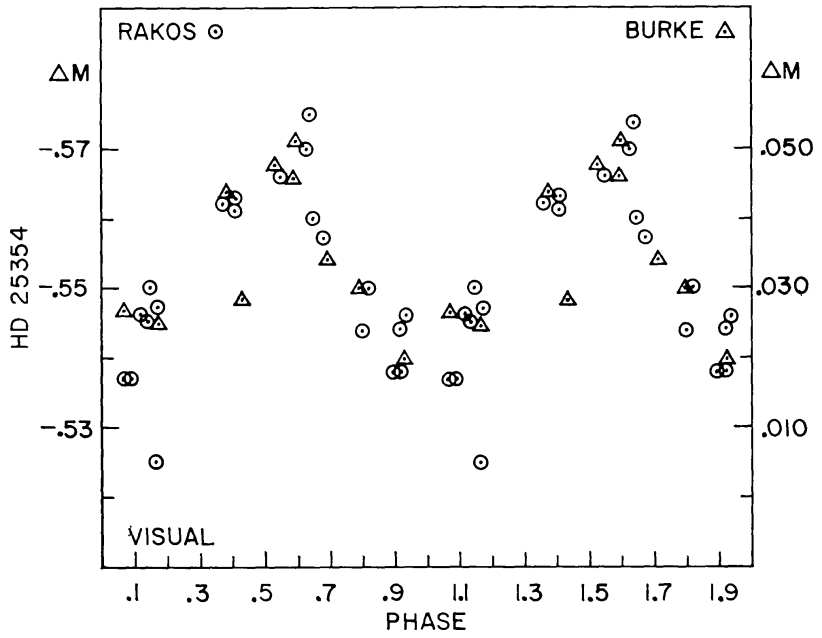

FIG. 3—Visual light curve for magnetic variable, HD 25354. All values are instrumental, not standard UBV. Circles represent the curve previously published by Rakos. Triangles are observations from this investigation where ΔM (at right) is HD 25643 − HD 25354. The vertical scale was adjusted to conform with the values of Rakos.

TABLE I

Magnetic Variable	Babcock Catalog No.	Star Δm	Visual: Average Δm	Visual: σ (Magnitude)	Visual: No. of Obs.	Visual: Total Nights in Obs. Run	Blue: Average Δm	Blue: σ (Magnitude)	Blue: No. of Obs.	Blue: Total Nights in Obs. Run	Figure Ref.
HD 90569 (45 LEONIS) Dec. 1967 Jan. 1968	36	HD 90569 − HD 90123	Prob. Var.	.007	8	18	Prob. Var.	.010	5	14	4
		HD 90123 − HD 90254	Var.	.012	8	18	Var.	.021	5	14	
HD 137909 (β Cr. B.) Dec. 1967 Jan. 1968	55	HD 136512 − HD 137909	1.835	.003	8	13	Var.	.012	8	13	5
		HD 136512 − HD 137107	.509	.002	8	13	Prob. Var.	.007	8	13	

± .0001. Figure 3 shows the observations from this investigation superimposed on the light curve published previously by Rakos (1962b).

C. Magnetic Stars Suspected to be Variable:

Two of the magnetic stars, 45 Leonis and β Coronae Borealis, show probable variation and are listed in Table I. They are shown in Figures 4 and 5 respectively. Provin (1953c) saw no variation of 45 Leonis in seven nights of observing. β CrB is of particular interest because Steinitz (1965)

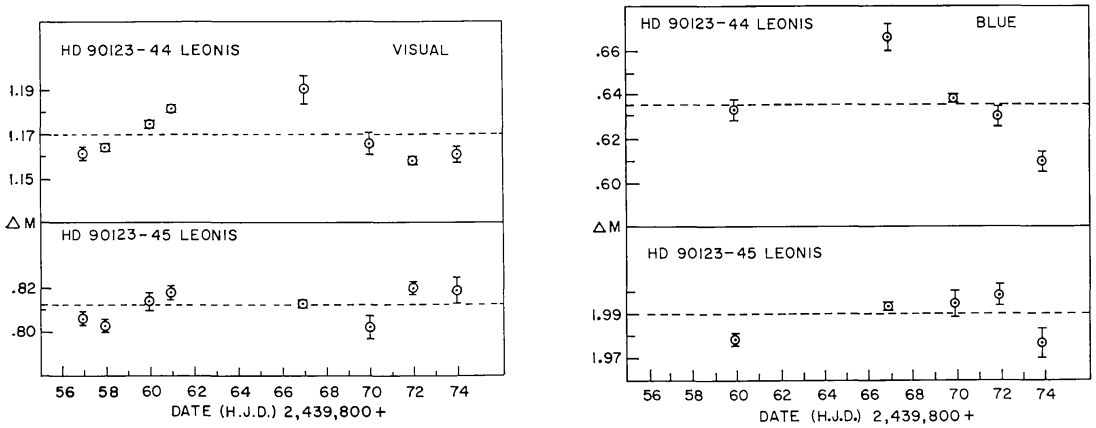

FIG. 4—Observations of magnetic variable, 45 Leonis (HD 90569). The lower curves show 45 Leonis to be slightly variable in visual and blue light. The upper curves show that comparison star, 44 Leonis (HD 90254), is variable in visual and blue light.

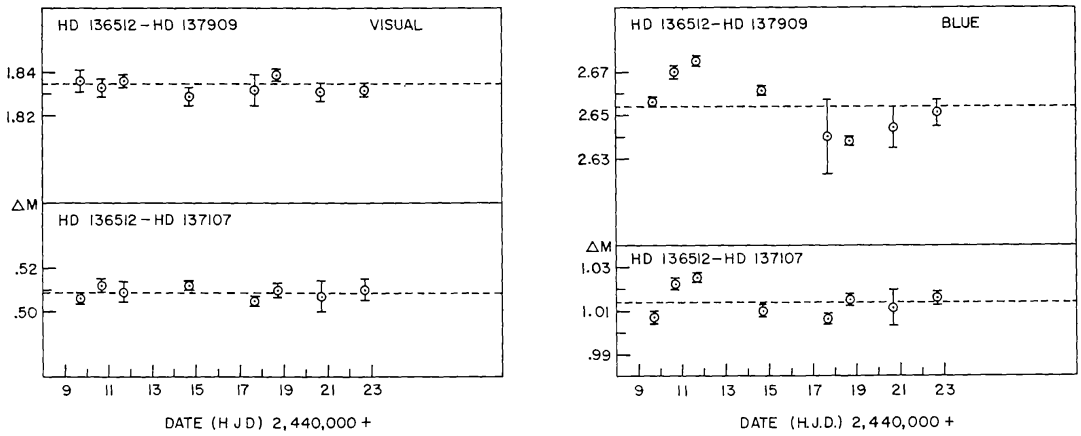

FIG. 5—Observations of magnetic variable, β Coronae Borealis (HD 137909), showing variability in blue.

found a spectroscopic period of 17.5 days for this star. On the basis of meagre photoelectric data, the same period appears possible with maximum blue light at about HJD 2,440,011.

D. Magnetic Stars with no Variability Detected:

The seven magnetic stars listed in Table II appear to be constant. A star was judged to be constant if the brightness difference between it and one of the comparison stars showed a small σ variation from the average value for the run. Examples of constant brightness stars can be seen in the bottom curves of Figures 6, 7, and 8. Dashed lines show average values.

E. Comparison Stars Discovered to be Variable:

Four stars chosen as comparison stars for this study are variable and are listed in Table III. Variation may be seen in the upper curves of Figures 4, 6, 7, and 8. Periodicity seems possible in all. They should be investigated spectroscopically and further photometric work should be done to verify the variation and to determine the type of each variable.

CONCLUSIONS

From a sample of eleven magnetic stars studied, two were determined to be periodic variables with amplitudes greater than $^{m}.03$ in at least one colour. Two others are suspected variables, while the seven remaining stars appear to be constant within the accuracy of our observations. Variations greater than $^{m}.015$ during the observing period should have been detected. Since very few magnetic stars have been reported constant in brightness, we had been led to believe that almost all magnetic stars would vary with larger amplitudes than $^{m}.015$. Thus it appeared that too many constant magnetic stars were detected in this investigation. By comparison Stepień, working

TABLE II

CONSTANT MAGNETIC STARS

Magnetic Variable	Babcock Catalog No.	Star △m	Visual: Average △m	Visual: σ (Magnitude)	Visual: No. of Obs.	Visual: Total Nights in Obs. Run	Blue: Average △m	Blue: σ (Magnitude)	Blue: No. of Obs.	Blue: Total Nights in Obs. Run	Figure Ref.
HD 20210	11	HD 20210 – HD 20468	1.363	.003	5	18	.2604	.002	4	13	
Dec. 1967 Jan. 1968		HD 19207 – HD 20468	3.012	.003	5	18	2.626	.005	4	13	
HD 42616	22	HD 42141 – HD 42616	.4688	.007	11	23	.5273	.005	11	23	
Dec. 1967 Jan. 1968 (1)		HD 42141 – HD 41636	1.251	.006	11	23	.4237	.004	11	23	
HD 68351 (15 Cancri)	29	HD 68254 – 15 Cancri	2.400	.004	11	23	2.519	.006	12	23	6
Dec. 1967 Jan. 1968 (2)		HD 68254 – HD 66216	.822	.008	11	23	1.600	.006	12	23	
HD 77350 (ν Cancri)	33	HD 77350 – HD 76333	1.296	.003	10	21	1.733	.002	5	15	7
Dec. 1967 Jan. 1968 (3)		HD 77694 – HD 76333	Var.	.012	10	21	Var.	.027	5	15	
HD 110066	40	HD 108408 – HD 110066	1.242	.005	10	18	1.338	.006	10	17	
Dec. 1967 Jan. 1968		HD 108408 – HD 110787	.566	.005	10	18	.4009	.004	10	17	
June 1968 (4)		HD 108408 – HD 110066	1.244	.006	10	13	1.344	.003	10	13	
		HD 108408 – HD 110787	.576	.003	10	13	.4020	.006	10	13	
HD 134793	53	HD 134793 – HD 134854	.672	.005	13	14	.762	.006	13	14	8
June 1968 (5)		HD 135576 – HD 134854	Prob. Var.	.006	13	14	Var.	.010	13	13	
HD 201601 (ν Equulei)	78	HD 201616 – HD 201601	1.379	.004	7	13	1.131	.002	7	13	
June 1968 (6)		HD 201616 – HD 202275	1.601	.002	7	13	1.097	.003	7	12	

(1) Provin (1953c) found no variation in yellow or blue. Some variation indicated in UV.
(2) Stepień (1968) found no variation in 15 Cancri in visual. Variation in B–V, $^{m}.015$, with period 4.12 days.
(3) Observation of ν Cancri and HD 77694 being continued.
(4) This is the only star which was observed at an interval of six months.
(5) Observations of HD 134793 and HD 135576 being continued.
(6) Wehlau (1962) found ν Equulei constant. This star was of particular interest because a magnetic period of about nine days has been established by Steinitz (1965).

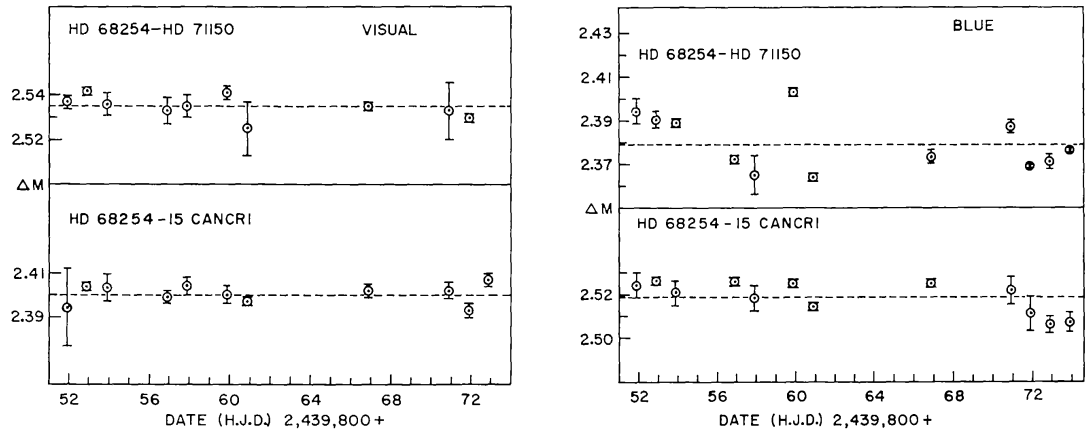

FIG. 6—Observations of magnetic variable, 15 Cancri (HD 68351). The star appears to be constant in visual and blue light. In the upper curves, comparison star, HD 71150–1, appears to be variable in blue light.

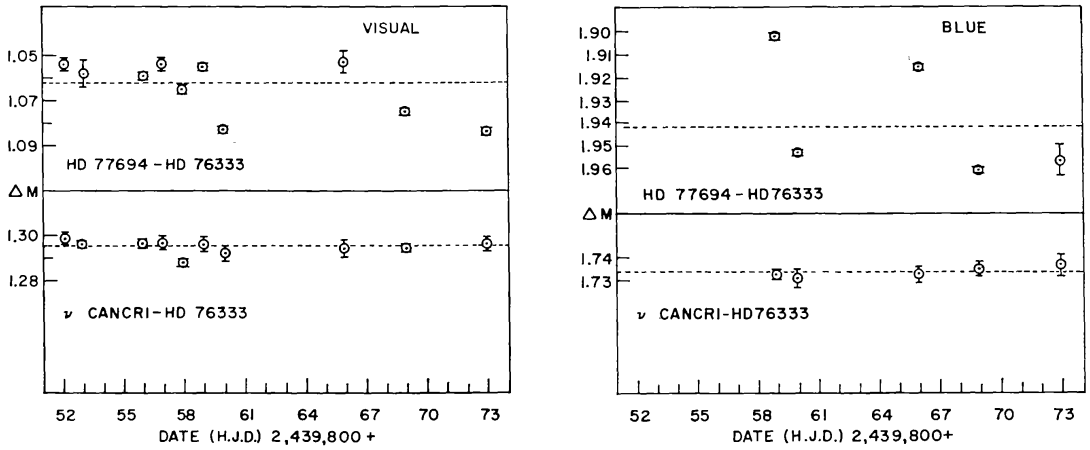

FIG. 7—Observations of magnetic variable star, ν Cancri (HD 77350), which appears to be constant. The upper curves show comparison star, HD 77694, to vary in both visual and blue light.

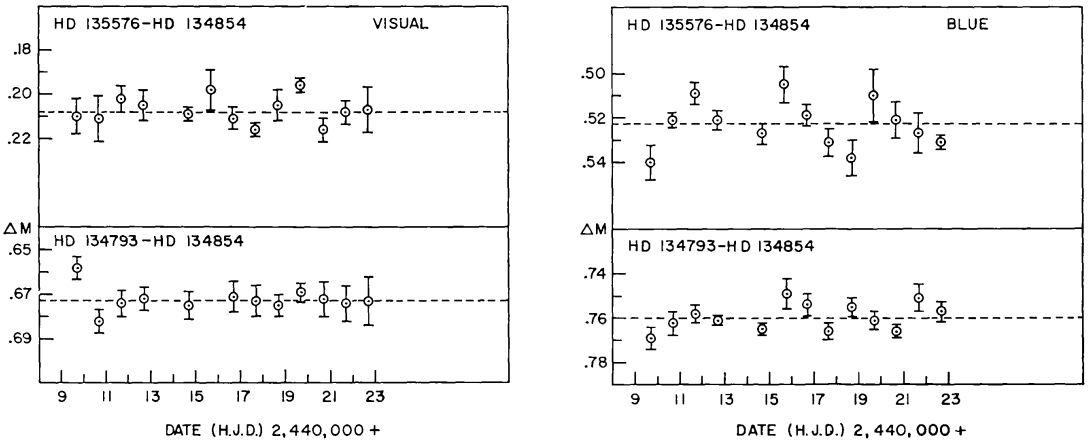

FIG. 8—Observations of magnetic star, HD 134793, indicate that it is probably constant in visual and blue light. In the upper curves, comparison star HD 135576 appears to be variable in both visual and blue light.

TABLE III

NEW VARIABLE STARS

Star	Spec. Type	Diff. Observed	Variation △M Visual	Variation △M Blue	Figure Ref.	Poss. Period
HD 71150–1	A2	HD 68554–HD 71150	.015	.033	6	
HD 77694	K0	HD 77694–HD 76333	.035	.054	7	
HD 90254 (44 LEONIS)	M0	HD90123–HD 90254	.032	.050	4	1.2-2.0 d.
HD 135576	F2	HD 135576–HD 134854	.019	.025	8	3.75 d.

concurrently with this investigation, reported only two of twenty-two to be constant. Dr. Abt suggested that the seeming discrepancy might be removed by analyzing the fact that the precision of Stepień's work was greater than ours. That appears to be correct.

First, we note that ten of the twenty-two stars Stepień (1968) observed had been previously reported variable by other observers; only twelve were unstudied. Of these twelve he found two to be constant, meaning that they did not vary as much as $^{m}.010$ in any colour. Six others showed periodic variations with amplitudes between $^{m}.010$ and $^{m}.015$; often in only one colour. This could mean that if we had looked at his sample of unstudied magnetic stars, we might have seen no variation in those eight. In our sample we saw none in seven of eleven, so results are similar.

This suggests that only a small fraction of the remaining unstudied Babcock Catalog stars is variable with an amplitude of more than $^{m}.015$ in blue or visual light. Photometric work with such precision is demanding of observing site, equipment, and techniques. However, it appears that periods for short period stars may not be determined by any other method.

Another important conclusion is that there are probably many undetected non-Ap variable stars with detectable variations under $^{m}.05$. Four of the arbitrarily chosen comparison stars show variability of from $^{m}.02$ to $^{m}.05$ in one or more colours. Four other comparison stars show large σ values for the run, and are probably slightly variable in at least one colour. Stepień (1968) also reports some difficulty finding dependable constant comparison stars.

TABLE IV

OBSERVATIONS OF HD 25354

VISUAL
(Instrumental Values)

(HD 25643 - HD 25354)

DATE H.J.D.	PHASE	Δ M	S.D.	N
2,439,000+				
852.685	.536	.048	.0051	4
853.692	.794	.030	.0031	4
856.771	.583	.054	.0091	4
858.682	.073	.027	.0024	4
860.686	.587	.046	.0044	4
867.676	.379	.044	.0059	4
870.683	.150	.025	.0050	4
871.779	.431	.029	.0074	3
872.779	.687	.034	.0101	3
873.665	.914	.020	.0037	3

OBSERVATIONS OF HD 30466

BLUE

(HD 30466 - HD 30379)

2,439,000+				
851.778	.000	.024	.0024	6
852.746	.696	.006	.0048	6
853.78	.440	-.010	.0026	6
856.790	.606	-.009	.0028	8
857.723	.277	.025	.0103	5
860.706	.423	-.015	.0027	8
866.827	.827	.014	.0050	6
867.827	.546	-.014	.0031	7
870.703	.615	-.019	.0026	7
871,748	.367	.003	.0060	6
872.755	.091	.019	.0014	3

VISUAL

2,439,000+				
851.778	.000	.377	.0020	2
852.34	.696	.375	.0047	7
853.762	.440	.370	.0026	6
856.809	.606	.363	.0022	8
860.727	.423	.358	.0029	4
867.705	.546	.370	.0040	5
870.718	.615	.368	.0019	6
871.768	.361	.375	.0033	4
872.767	.091	.381	.0014	4
873.77	.813	.365	.0016	4

TABLE IV (Continued)

OBSERVATIONS OF HD 68351 (15 Cancri)

BLUE

DATE H.J.D.	(HD 68254 - HD 71150) Δ M	S.D.	N	(HD 68254 - HD 68351) Δ M	S.D.	N
2,439,000+						
851.901	2.394	.006	2	2.524	.006	4
852.93	2.390	.004	2	2.526	.002	3
853.873	2.389	.002	2	2.521	.005	3
856.887	2.372	.001	2	2.526	.002	4
857.897	2.365	.009	2	2.518	.006	4
859.897	2.403	.0002	2	2.525	.002	3
860.885	2.364	.003	2	2.514	.002	4
866.899	2.373	.003	2	2.525	.002	5
870.883	2.386	.003	4	2.522	.007	3
871.884	2.369		1	2.511	.008	4
873.888	2.376	.001	2	1.507	.004	2
VISUAL						
2,439,000+						
851.904	2.537	.003	2	2.394	.017	2
852.93	2.541	.0001	2	2.404	.002	3
853.873	2.536	.005	5	2.403	.006	8
856.887	2.533	.006	2	2.399	.003	4
857.892	2.535	.005	2	2.404	.004	4
859.897	2.541	.003	3	2.400	.004	3
860.885	2.525	.012	2	2.397	.002	4
866.899	2.535		1	2.402	.004	4
870.883	2.533	.013	2	2.402	.004	3
871.884	2.530		1	2.393	.003	4
872.896				2.407	.003	3

OBSERVATIONS OF HD 77350 (ν Cancri)

BLUE

	(HD 77694 - HD 76333)			(HD 77350 - HD 76333)		
2,439,000+						
858.928	1.902	.0016	3	1.732	.0027	4
859.929	1.954	.0059	2	1.730	.0040	4
865.935	1.916	.0020	2	1.732	.0034	3
868.911	1.961	.0032	2	1.733	.0030	4
872.924	1.957	.0070	3	1.736	.0042	4

TABLE IV (Continued)

OBSERVATIONS OF HD 77350 CONTINUED

VISUAL

DATE H.J.D.	(HD 77694 - HD 76333) Δ M	S.D.	N	(HD 77350 - HD 76333) Δ M	S.D.	N
2,439,000+						
851.900	1.054	.0035	2	1.299	.0026	4
852.940	1.058	.0059	3	1.296	.0021	8
855.943	1.059	.0020	2	1.297	.0025	4
856.921	1.054	.0028	2	1.297	.0030	4
857.941	1.065	.0027	2	1.288	.0025	4
858.938	1.055	.0016	2	1.298	.0033	3
859.938	1.083	.0021	2	1.296	.0024	4
865.952	1.053	.0054	3	1.297	.0036	4
868.919	1.075	.0003	2	1.297	.0019	4
872.937	1.084	.0010	2	1.298	.0035	3

OBSERVATIONS OF HD 90569 (45 Leonis)

BLUE

	(HD 90123 - HD 90254)			(HD 90123 - HD 90569)		
2,439,000+						
859.988	.633	.005	2	1.979	.003	3
866.971	.666	.006	4	1.994	.002	4
869.932	.638	.002	5	1.995	.006	4
871.937	.630	.005	5	1.999	.005	5
873.957	.609	.005	4	1.977	.007	4

VISUAL

2,439,000+						
856.990	1.161	.0030	2	.8060	.003	5
857.976	1.164	.0014	2	.8030	.003	5
859.965	1.175	.0020	2	.8124	.004	4
860.968	1.182	.0014	2	.8180	.003	5
866.986	1.191	.0057	4	.8134	.002	4
869.946	1.166	.0054	4	.8025	.005	4
871.954	1.158	.0021	4	.8200	.003	4
873.974	1.612	.0036	3	.8190	.006	3

TABLE IV (Continued)

OBSERVATIONS OF HD 134793

DATE H.J.D.	(HD 135576 - HD 134854) ΔM	S.D.	N	(HD 134793 - HD 134854) ΔM	S.D.	N
BLUE						
2,440,000+						
9.710	.540	.008	3	.769	.005	4
10.749	.521	.003	3	.762	.005	3
11.68	.509	.005	3	.758	.004	3
12.744	.521	.004	3	.761	.002	4
14.721	.527	.0052	4	.765	.003	6
15.798	.505	.008	3	.749	.007	4
16.744	.519	.005	4	.754	.005	5
17.659	.531	.006	3	.766	.004	5
18.726	.528	.008	3	.755	.004	4
19.713	.510	.012	3	.761	.004	4
20.718	.521	.008	3	.766	.002	4
21.710	.527	.009	4	.751	.006	4
22.7	.531	.003	4	.757	.004	4
VISUAL						
2,440,000+						
9.710	.210	.008	4	.658	.005	4
10.749	.211	.010	4	.682	.005	4
11.68	.202	.006	4	.674	.006	4
12.744	.205	.007	4	.672	.005	4
14.721	.209	.002	5	.675	.006	6
15.798	.198	.009	3	.699	.009	5
16.744	.211	.005	3	.671	.007	6
17.659	.216	.003	5	.673	.007	6
18.726	.205	.007	4	.675	.005	4
19.713	.196	.002	3	.669	.004	3
20.718	.216	.005	3	.672	.008	3
21.710	.208	.005	4	.674	.008	4
22.700	.207	.010	4	.673	.011	4

TABLE IV (Continued)

OBSERVATIONS OF HD 137909 (β Cr. B.)						
BLUE						
	(HD 136512 - HD 137107)			(HD 136512 - HD 137909)		
DATE H.J.D.	ΔM	S.D.	N	ΔM	S.D.	N
2,440,000+						
9.750	1.007	.0021	4	2.656	.0026	4
10.785	1.022	.0032	3	2.670	.0030	4
11.740	1.025	.0023	4	2.675	.0023	4
14.762	1.010	.0020	3	2.661	.0010	4
17.716	1.006	.0028	3	2.640	.0169	3
18.783	1.015	.0023	4	2.638	.0011	4
20.784	1.011	.0080	4	2.644	.0094	4
22.780	1.016	.0032	3	2.651	.0063	4
VISUAL						
2,440,000+						
9.750	.506	.0004	4	1.836	.0050	4
10.785	.512	.0030	4	1.833	.0043	4
11.740	.509	.0037	4	1.836	.0033	4
14.762	.512	.0010	2	1.829	.0040	3
17.716	.505	.0014	4	1.832	.0071	4
18.783	.510	.0026	3	1.839	.0014	3
20.784	.507	.0067	3	1.831	.0038	4
22.700	.510	.0050	2	1.832	.0030	2

OBSERVATIONS OF HD 184905							
ULTRAVIOLET							
		(HD 184905 - HD 184875)			(HD 185872 - HD 184875)		
DATE H.J.D.	PHASE	ΔM	S.D.	N	ΔM	S.D.	N
2,440,000+							
9.9659	.229	.941	.0024	3	.288		1
10.9247	.720	.946	.0041	3	.287	.0056	4
11.9282	.270	.932	.0066	4	.282	.0020	4
13.9144	.351	.902	.0084	4	.291	.0055	3
17.8995	.500	.891	.0049	4	.285	.0049	3
18.9478	.050	.934	.0034	4	.289	.0009	3
19.9216	.595	.910	.0018	5	.287	.0041	3
20.9123	.145	.939	.0050	4	.284	.0080	3
21.9026	.208	.940	.0063	4	.281	.0040	3
22.9026	.208	.940	.0063	4	.281	.0040	3

TABLE IV (Continued)

OBSERVATIONS OF HD 184905 CONTINUED

BLUE

DATE H.J.D.	PHASE	Δ M	S.D.	N		Δ M	S.D.	N
2,439,000+		Values Adjusted						
36.9787	.162	1.208						
39.9572	.768	1.191						
42.9525	.382	1.178						
54.9162	.832	1.213						
56.9446	.925	1.207						
57.7981	.386	1.183						
57.8982	.439	1.178						
58.9011	.980	1.207						
62.8837	.127	1.205						
63.9153	.683	1.200						
2,440,000+								
9.9566	.229	1.206	.0024	3		.052	.0005	3
10.8687	.720	1.202	.0059	7		.050	.0062	6
11.8886	.270	1.196	.0134	5		.053	.0047	5
13.8953	.352	1.188	.0031	4		.050	.0058	4
17.8797	.500	1.185	.0061	5		.055	.0022	3
18.9002	.050	1.212	.0018	4		.052	.0067	4
19.9115	.595	1.198	.0052	4		.050	.0021	3
20.8760	.145	1.201	.0026	4		.054	.0055	3
21.9085	.671	1.200	.0068	4		.050	.0062	3
22.9026	.208	1.205	.0020	4		.048	.0053	3

VISUAL

2,440,000+								
9.9433	.229	1.304	.0012	2		.067		1
10.8999	.720	1.301	.0037	4		.066	.0041	3
11.9019	.270	1.298	.0039	3		.062	.0029	4
12.7795	.756	1.310	.0040	4		.066	.0089	3
13.8865	.352	1.278	.0049	4		.067	.0044	3
17.8560	.500	1.261	.0062	4		.063	.0064	4
18.8499	.050	1.303	.0036	4		.064	.0012	4
19.9428	.595	1.287	.0023	3		.063	.0022	2
20.8966	.145	1.307	.0066	3		.070	.0042	2
21.9276	.671	1.295	.0042	4		.064	.0037	3
22.8672	.208	1.303	.0031	4		.064	.0056	3

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