Short-Period Variability of B, A, and F Stars. II. Photometry of New Delta Scuti Stars*

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Photoelectric data for 15 more short-period variables, as well as one suspected variable discovered during a recent variability survey amongst bright field stars, are given. The periods range from 0.042 to 0.16 days and some amplitudes are as small as 0.01 mag in visual light.

VERY little is known about the variability of stars in the instability strip below the RR Lyrae region in the H–R diagram. Two types of pulsating variables are generally recognized in that region: Dwarf Cepheids and δ Scuti stars (Eggen 1956). Apart from the four δ Scuti stars listed by Eggen, several more have recently been found by Danziger and Dickens (1967), Millis (1967), and Eggen (1968). Periods for δ Scuti stars are less than 0.2 days, and amplitudes are typically several hundredths of a magnitude. A program to investigate the variability of about 300 field and cluster stars, mainly of spectral-type A and F, was started in 1966. In this paper, data for the short-period variables detected in the field survey are presented. The discussion of the properties of these and other known short-period variables will be made in a later paper in this series.

A number of telescopes were used: The 24-inch reflector at the Lick Observatory, the Nos. 1 and 2 36-inch reflectors, as well as the No. 4 16-inch telescope at the Kitt Peak National Observatory. Most observations were made only in the instrumental V-magnitude system with a few stars also being measured in the UBV and $uvby$ systems. Only one color was usually measured in order to obtain higher accuracy. Furthermore, since the amplitude of variation for these variables is very small, it was thought that little was to be gained by transforming the observations to the UBV system, since the errors of transformation may be as large as the amplitude. At least two (nonvariable) comparison stars were used for each variable and each observation consisted of a mean between six and ten 10-second integrations. At the Lick Observatory, a radium source was used to determine sensitivity changes during the night. Extinctions were derived for every night. The typical mean absolute error per *single* observation in the V was 0.001–0.002 mag.

The field stars discovered to be variable are listed in Table I, where the columns are self explanatory. Because of the presence of beat periods in many δ Scuti stars, the periods listed in Table I are estimated to be correct only within $\pm 8\%$.

The individual observations of 15 of the 16 short-period variables are listed in Table II and shown plotted in Figs. 1–7. The variability of the 16th star,

TABLE I. Short-period variables found during the field-star survey, presumably of the δ Scuti type.

HR	Name	Spectrum	Period	Mean amplitude
114	28 And	Am	0.069	0.035
432	97 Psc	A4 III	0.16	0.02
515		A7n	0.16	0.015
729	26 Ari	A4n	0.06	0.03
1170		F0	0.091	0.08
1223		A5	0.046	0.01
5017	20 CVn	F0 II–IIIp	(.14)	0.03
5960		F0 IV	0.069	0.02
6391	63 Her	A3	0.077	0.025
7222		F2	0.096	0.04
7331	28 Aql	F0	0.1574	0.05
7501		F0	0.082	0.01
7563		F0 III	0.100	0.05
8006		F0	0.06	0.03
8494	ϵ Cep	F0 IV	0.042	0.02
8584		A5	0.056	0.02
8666*		dA8	(.052)	(.01)

* Suspected variable.

Notes to Individual Stars

HR 114: This star was also found to be variable by Nishimura (private communication). HR 114 is the first metallic-line A star found to have a δ Scuti-like variability. The radial velocity varies by 5 km/sec with the same period. Although metallic-line A stars usually have large negative Δm_1 values [a measure of metal-line strengths as defined by Strömgren (1963)], for HR 114 $\Delta m_1 = +.013$. It has recently been suggested that all Am stars are spectroscopic binaries (Abt 1961); however, the available radial-velocity data for HR 114 show no velocity variations apart from the small pulsational variation.

HR 432: Bluest δ Scuti star known so far [A4 III, $(b-y) = 0.090$].

HR 515: Wilson and Joy (1950) found an indication for variable velocity (-14 to $+19$ km/sec), but their measurements are not conclusive. The velocity variation could be caused by pulsation and/or the line differences in the measured spectra.

HR 1170: This star was observed with the four-channel simultaneous *uvby* photometer attached to the No. 2 36-inch reflector at the Kitt Peak National Observatory. The mean variations in $(b-y)$ and c_1 indices (the c_1 index is a measure of the Balmer jump and hence of surface gravity) were 0.020 and 0.047 mag, respectively, while the m_1 index showed no significant variation. It is interesting to transform these intrinsic variations to M_v using the Strömgren calibration (Strömgren 1963). The $(b-y)$ and c_1 indices indicate a variation of 0.076 mag in the absolute magnitude M_v. This compares very favorably with the *measured* mean visual amplitude of 0.08 mag. This indicates that the Strömgren calibration of color and Balmer jump, made by comparing different stars, is applicable even to the small pulsational changes in one star.

HR 1223: The light variation on J.D. 2439782 is shown in Fig. 1. Measurements on J.D. 2439787 and 2439789 indicate strong semiregular variations of between 0.01 and 0.02 mag. The period derived from the first night is still clearly evident, but secondary bumps are also visible.

HR 5017: After the star was found to be variable, no further observations were made when information was received that Dickens was also observing this star.

HR 5960: Also found to be variable by Millis (1967).

HR 7501: This star has a very small variable amplitude of about 0.01 mag, which at times approaches the limits of detectability.

HR 8494: Light curve was published previously (Breger 1966). Danziger and Dickens (1967) listed this star as "? Var.," while Millis (1967) found small inconclusive variations. The velocity curve is shown in Fig. 8.

HR 8584: Spectroscopic binary, period 2.3 days.

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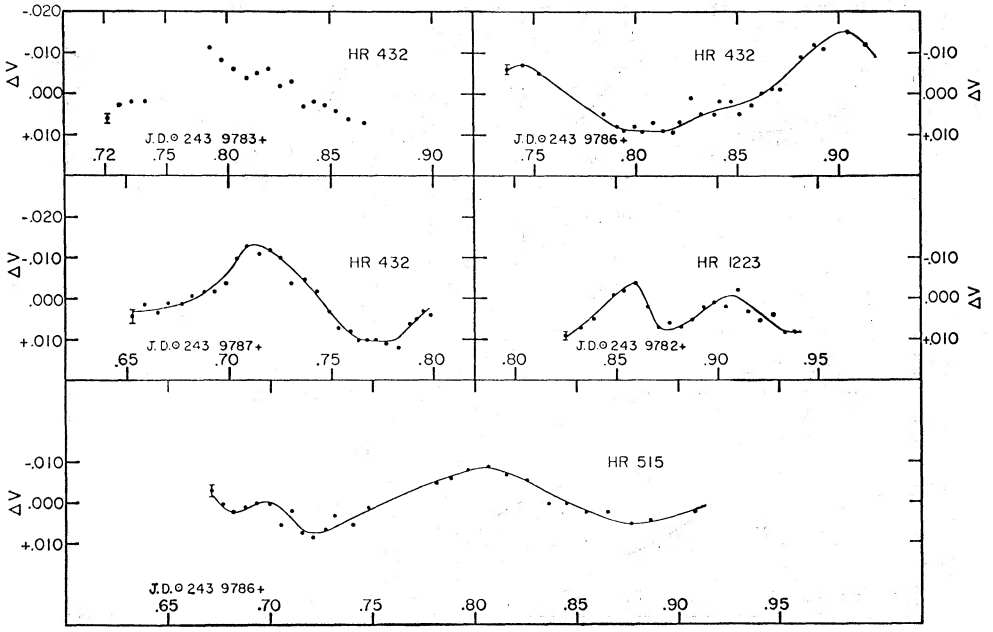

FIG. 1. Light variations of HR 432, HR 515, and HR 1223: All light curves are drawn free-hand.

ϵ Cep (=HR 8494), has already been announced (Breger 1966). The error bars shown in the figures refer to the mean absolute error per single observation as derived from the comparison stars. Since several different telescopes were used, many observations are listed only as ΔV (relative to an unknown V magnitude). However, when a star was observed on more than one night, the ΔV magnitudes always refer to

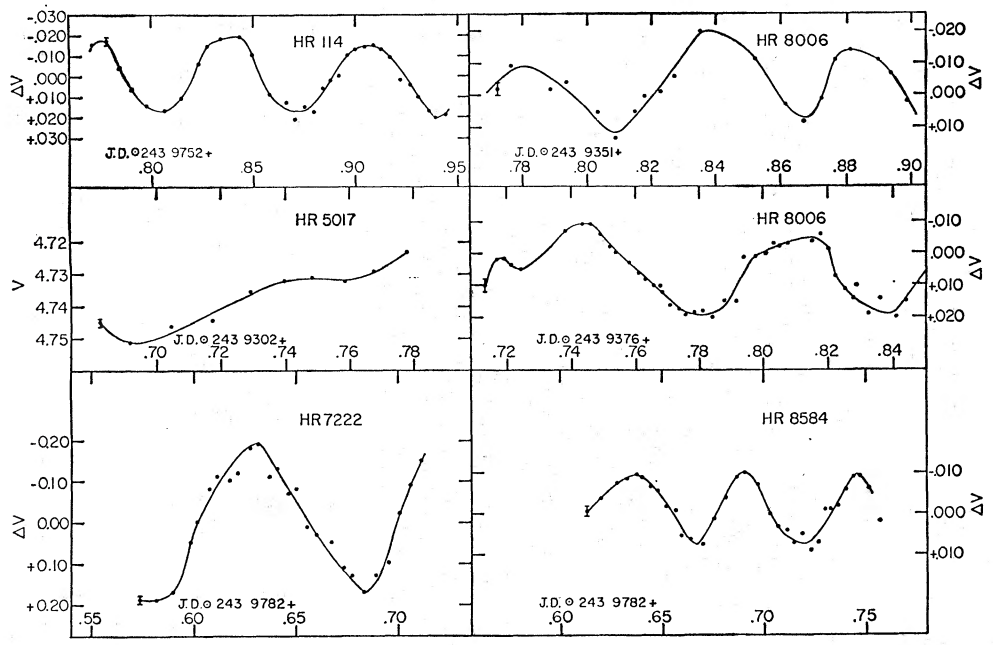

FIG. 2. Light variations of HR 114, HR 5017, HR 7222, HR 8006, and HR 8584.

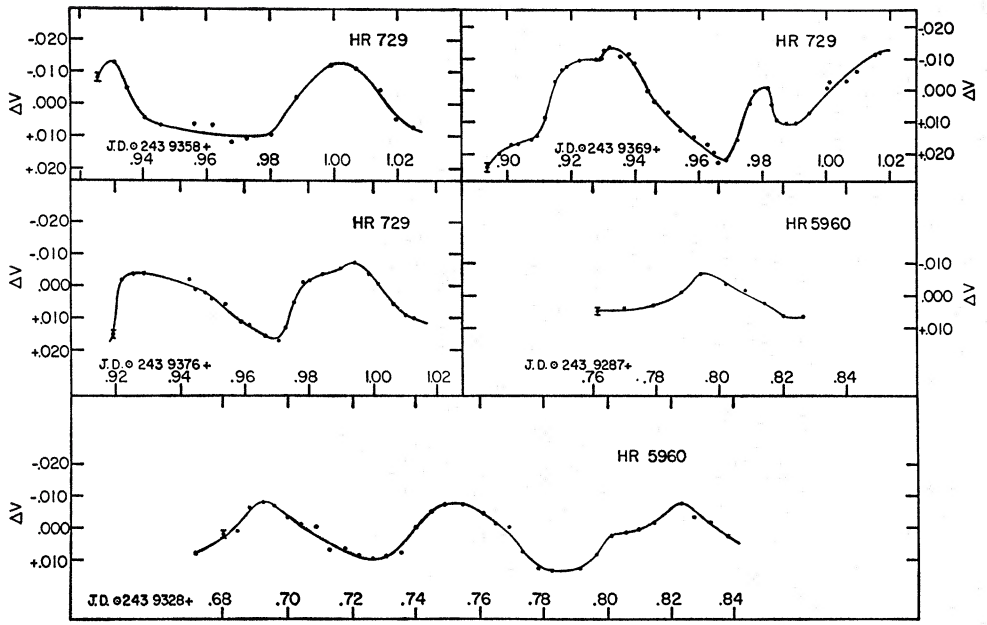

FIG. 3. Light variations of HR 729 and HR 5960.

the same zero point (except for HR 7563). For most of these stars, *UBV* and/or *uvby* measurements were obtained separately (Breger 1968). The observations of the suspected variable, HR 8666, on two nights are shown plotted in Fig. 4.

Abt (1965) has investigated the radial velocity of many A stars for variability to detect possible binary nature. The velocity variations caused by pulsation are typically 5 km/sec and are generally too small to be detected by Abt's binary search because the radial-

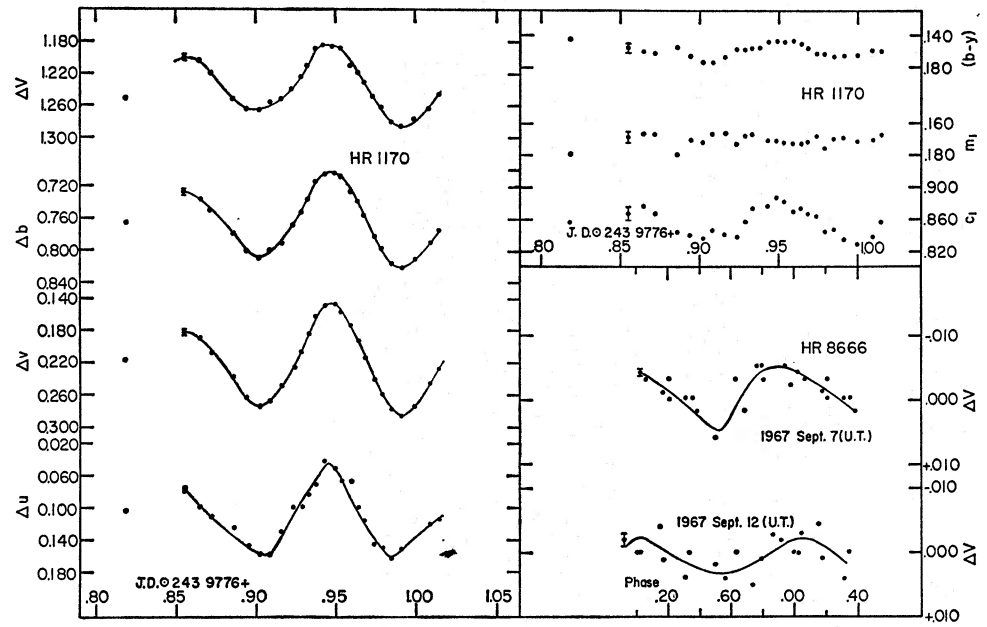

FIG. 4. Light variations of HR 1170 and the suspected variable HR 8666 using a period of 0.052 days: The light variations of HR 1170 are in the narrow-band *uvby* system and the variations of the indices $(b-y)$, m_1, c_1 are also shown.

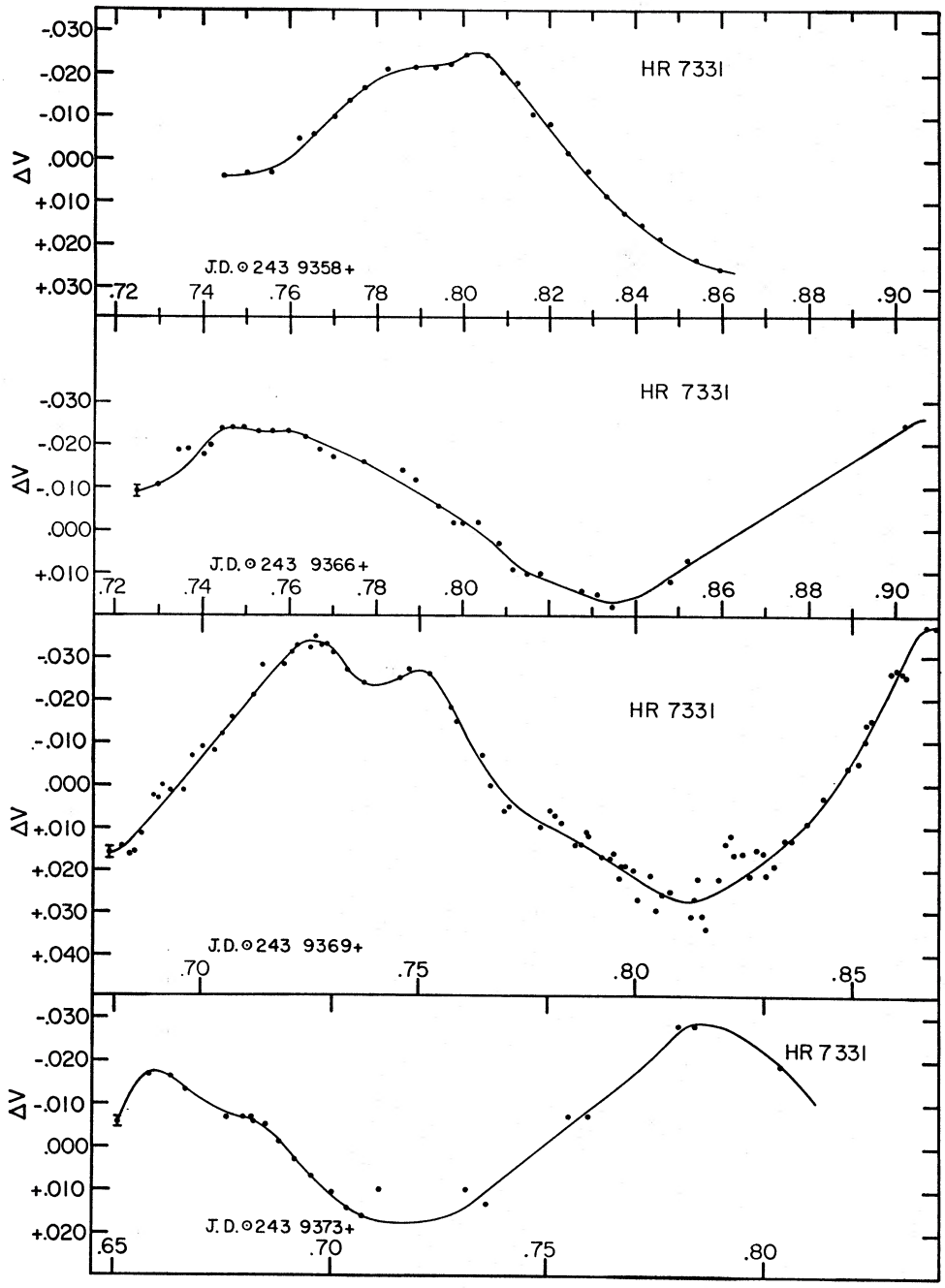

FIG. 5. Light variations of HR 7331.

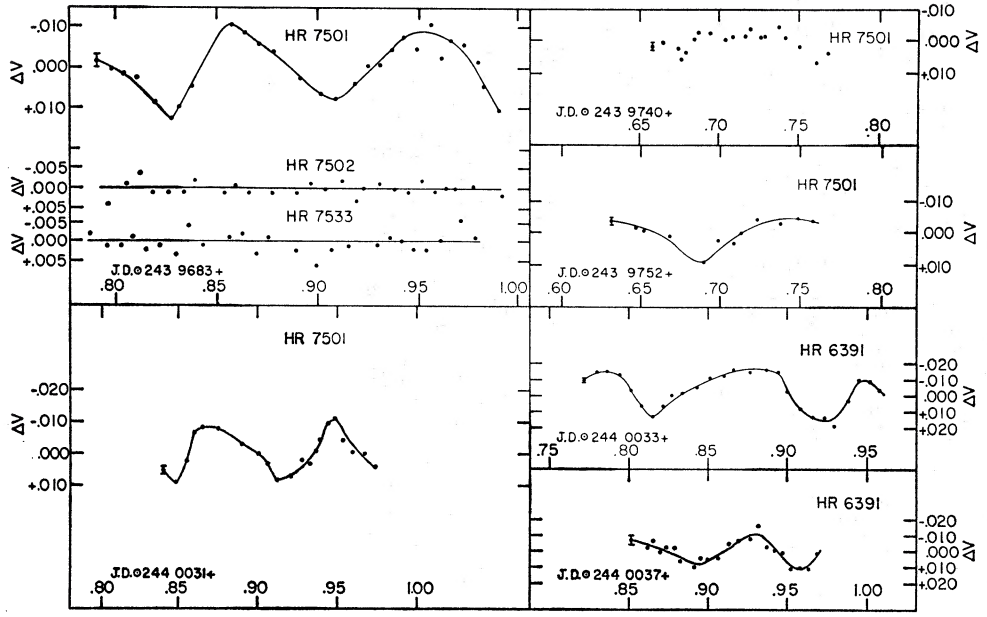

FIG. 6. Light variations of HR 7501 and HR 6391: The two comparison stars used for HR 7501 are also shown.

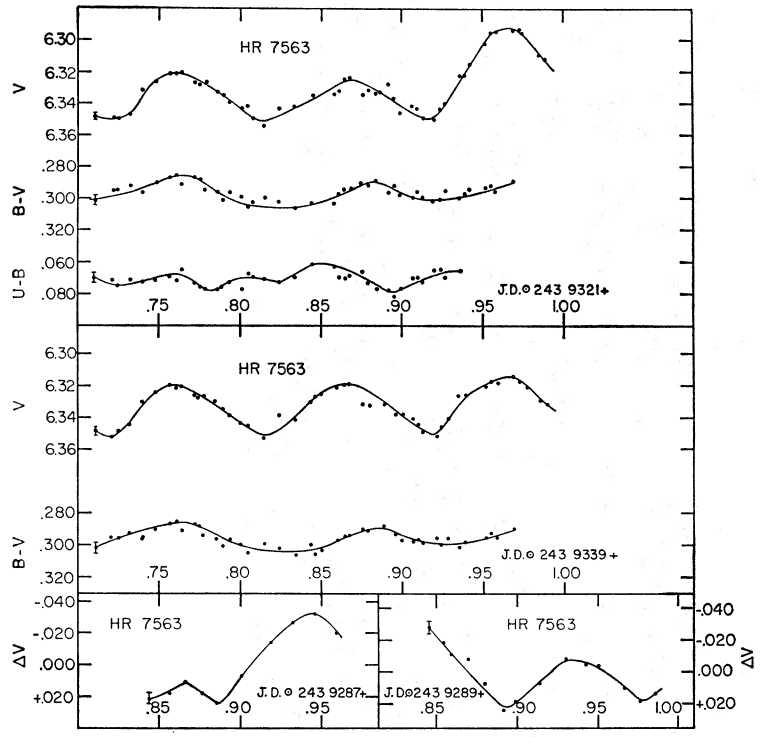

FIG. 7. Light variations of HR 7563.

TABLE II. Photometry of the new variables.

HR 114=28 And, J.D.⊙	Comparison Stars: HR 44, 71, 9025 ΔV
243 9752.7715	−.016
.7778	−.018
.7840	−.005
.7903	+.006
.7972	+.014
.8063	+.016
.8146	+.007
.8229	−.007
.8271	−.015
.8340	−.019
.8431	−.020
.8493	−.011
.8576	+.008
.8660	+.012
.8701	+.020
.8743	+.014
.8785	+.016
.8833	+.005
.8875	+.002
.8917	−.001
.8958	−.011
.9000	−.013
.9042	−.015
.9083	−.016
.9125	−.014
.9167	−.010
.9215	+.001
.9264	+.003
.9306	+.010
.9354	+.017
.9396	+.019
.9438	+.018

HR 432 = 97 Psc J.D.⊙	Comparison stars: HR 308, 457, 522 ΔV
243 9783.7215	+.006
.7271	+.003
.7333	+.002
.7396	+.002
.7715	−.011
.7778	−.008
.7833	−.006
.7889	−.004
.7944	−.005
.8000	−.006
.8056	−.002
.8118	−.003
.8174	+.003
.8222	+.002
.8278	+.003
.8333	+.004
.8389	+.006
.8465	+.007
243 9786.7386	−.006
.7444	−.007
.7521	−.005
.7840	+.005
.7903	+.008
.7938	+.009
.7993	+.008
.8028	+.009
.8083	+.007
.8132	+.009
.8181	+.009
.8215	+.007
.8271	+.001

HR 432 = 97 Psc J.D.⊙	Comparison stars: HR 308, 457, 522 ΔV
243 9786.8319	+.005
.8382	+.005
.8417	+.002
.8472	+.002
.8514	+.005
.8569	+.003
.8618	.000
.8674	−.001
.8715	−.001
.8806	−.009
.8882	−.012
.8924	−.011
.9042	−.015
.9132	−.012
243 9787.6528	+.004
.6583	+.001
.6646	+.003
.6701	+.001
.6764	+.001
.6819	−.001
.6875	−.002
.6931	−.002
.6986	−.004
.7035	−.010
.7090	−.013
.7146	−.011
.7201	−.012
.7250	−.010
.7306	−.004
.7375	−.005
.7431	−.002
.7486	+.003
.7535	+.007
.7597	+.008
.7632	+.010
.7674	+.010
.7715	+.010
.7771	+.011
.7826	+.012
.7882	+.006
.7917	+.005
.7951	+.003
.7986	+.004
.8021	+.003
.8056	+.001
.8125	−.005
.8181	−.004

HR 515 J.D.⊙	Comparison stars: HR 457, 522 ΔV
243 9786.6708	−.003
.6764	.000
.6819	+.002
.6875	+.001
.6931	.000
.6993	.000
.7049	+.005
.7104	+.002
.7153	+.007
.7208	+.008
.7264	+.006
.7319	+.003
.7403	+.005
.7479	+.001
.7806	−.005
.7882	−.006

HR 515 J.D.⊙	Comparison stars: HR 457, 522 ΔV
243 9786.7972	−.008
.8069	−.009
.8160	−.007
.8257	−.006
.8361	.000
.8451	.000
.8549	+.002
.8653	+.002
.8764	+.005
.8861	+.004
.9083	+.002

HR 729 = 26 Ari J.D.⊙	Comparison stars: HR 646, 676, 783 ΔV
243 9358.9259	−.008
.9307	−.013
.9349	−.005
.9404	+.004
.9453	+.006
.9557	+.006
.9613	+.006
.9675	+.011
.9724	+.010
.9800	+.009
.9877	−.003
.9988	−.013
243 9359.0067	−.012
.0144	−.005
.1089	+.004
.0245	+.006
243 9369.8935	+.023
.8956	+.013
.8991	+.015
.9012	+.016
.9032	+.016
.9067	+.014
.9081	+.015
.9088	+.015
.9095	+.012
.9116	+.008
.9144	−.003
.9164	−.004
.9171	−.007
.9185	−.008
.9227	−.010
.9282	−.010
.9289	−.010
.9296	−.011
.9310	−.013
.9324	−.014
.9362	−.011
.9383	−.011
.9401	−.009
.9442	.000
.9463	+.003
.9498	+.003
.9512	+.009
.9526	+.007
.9560	+.017
.9581	+.013
.9588	+.015
.9602	+.013
.9651	+.019
.9664	+.022
.9685	+.016

TABLE II (*continued*)

HR 729 = 26 Ari J.D.⊙	Comparison stars: HR 646, 676, 783 ΔV
243 9369.9720	+.010
.9762	+.004
.9776	.000
.9817	−.001
.9831	+.004
.9845	+.009
.9880	+.010
.9901	+.010
.9914	+.010
.9921	+.013
.9984	+.001
243 9370.0005	−.001
.0012	−.003
.0026	−.004
.0088	−.005
.0102	−.002
.0109	−.007
.0151	−.012
.0164	−.011
.0171	−.012
243 9376.9191	+.015
.9219	−.002
.9254	−.004

HR 729 = 26 Ari J.D.⊙	Comparison stars: HR 646, 676, 783 ΔV
243 9376.9288	−.004
.9427	−.002
.9448	+.001
.9476	+.002
.9497	+.004
.9538	+.005
.9587	+.011
.9615	+.012
.9663	+.015
.9705	+.017
.9726	+.013
.9754	+.005
.9782	−.001
243 9376.9802	−.002
.9844	−.004
.9900	−.006
.9948	−.008
.9990	−.004
243 9377.0018	−.001
.0066	+.005
.0101	+.009
.0129	+.010

HR 1223 J.D.⊙	Comparison stars: HR 1133, 1234 ΔV
243 9782.8757	+.006
.8813	+.007
.8868	+.005
.8924	+.002
.8979	+.001
.9035	+.002
.9097	−.002
.9146	+.003
.9208	+.005
.9271	+.004
.9326	+.008
.9375	+.008
243 9787.8292	−.002
.8333	−.003
.8347	−.001
.8382	+.002
.8396	+.003
.8431	+.006
.8444	+.008
.8486	+.011
.8521	+.010
.8556	+.004
.8590	.000
.8604	.000
.8618	.000
.8660	.000
.8674	−.003
.8688	+.001
.8701	+.001
.8736	+.003
.8757	+.003
.8771	+.004
.8785	+.003
.8819	+.001
.8861	+.001
.8889	+.003
.8294	+.007
.8938	+.010
.8951	+.010
.8972	+.008
.9028	+.007
.9049	+.004
.9063	+.004
.9076	+.003
.9111	+.004
.9125	+.004
.9139	+.004
.9153	+.005
.9164	+.007
.9208	+.003
.9222	+.001
.9236	+.001
.9271	+.000
.9292	+.000
.9306	+.002
.9319	+.002
.9333	+.002
.9375	+.004
.9389	+.005
.9410	+.005
.9424	+.005
243 9789.8451	+.006
.8493	+.006
.8542	+.008
.8590	+.008
.8625	+.010
.8674	+.012
.8715	+.014
.8729	+.014
.8743	+.018

HR 1170 J.D.⊙	Comparison star: HR 1306 ΔV	$(b-y)$	c_1	m_1
243 9776.7576	1.209	.166	0.860	0.166
.8181	1.250	.146	0.856	0.180
.8549	1.200	.156	0.867	0.169
.8646	1.203	.162	0.875	0.167
.8715	1.218	.163	0.867	0.167
.8854	1.251	.156	0.843	0.180
.8938	1.264	.167	0.840	0.171
.9021	1.264	.174	0.836	0.172
.9083	1.255	.174	0.845	0.167
.9160	1.251	.167	0.842	0.167
.9229	1.239	.158	0.837	0.174
.9285	1.224	.159	0.856	0.168
.9326	1.210	.156	0.873	0.167
.9375	1.189	.155	0.885	0.167
.9431	1.185	.149	0.876	0.171
.9487	1.185	.148	0.887	0.172
.9528	1.188	.149	0.882	0.175
.9590	1.209	.147	0.870	0.175
.9639	1.218	.151	0.873	0.176
.9681	1.230	.157	0.867	0.172
.9736	1.249	.163	0.864	0.168
.9785	1.262	.163	0.845	0.176
.9847	1.280	.166	0.848	0.170
.9910	1.286	.165	0.834	0.169
.9993	1.276	.165	0.829	0.171
243 9777.0090	1.262	.158	0.837	0.171
.0146	1.245	.160	0.858	0.167

HR 1223 J.D.⊙	Comparison stars: HR 1133, 1234 ΔV
243 9782.8243	+.009
.8313	+.007
.8380	+.005
.8479	−.001

HR 1223 J.D.⊙	Comparison stars: HR 1133, 1234 ΔV
243 9782.8535	−.002
.8590	−.004
.8646	+.002
.8701	+.007

TABLE II (*continued*)

HR 1223 J.D.⊙	Comparison stars: HR 1133, 1234 ΔV
243 9789.8778	+.008
.8799	+.004
.8813	.000
.8868	+.002
.8882	+.004
.8896	+.008
.8944	+.011
.8965	+.011
.9007	+.005
.9021	+.005
.9042	+.005
.9076	+.004
.9090	+.002
.9111	+.007
.9146	+.012
.9160	+.014
.9202	+.012
.9236	+.013
.9250	+.012
.9292	+.007
.9313	+.005
.9326	+.005
.9347	+.001
.9361	+.001

HR 5017 = 20 CVn J.D.⊙	Comparison star: HR 5004 ΔV
243 9302.6821	+.009
.6918	+.016
.7041	+.011
.7175	+.009
.7293	.000
.7397	−.003
.7481	−.002
.7585	−.003
.7675	−.006
.7779	−.012
243 9304.6875	+.017
.7021	+.005
.7263	−.005
.7646	+.008

HR 5960 J.D.⊙	Comparison stars: HR 5964, 6127 ΔV
243 9287.7614	+.006
.7697	+.005
.7794	+.004
.7878	−.001
.7940	−.006
.8016	−.003
.8079	−.001
.8141	+.003
.8204	+.007
.8260	+.007
243 9288.7919	+.003
243 9302.7339	−.003
.7533	−.006
.7631	+.001
.8075	−.004
243 9328.6714	+.008
.6797	+.002
.6839	+.001
.6880	−.006

HR 5960 J.D.⊙	Comparison stars: HR 5964, 6127 ΔV
243 9328.6922	−.008
.6957	−.007
.6999	−.003
.7040	−.001
.7089	.000
.7130	+.007
.7172	+.007
.7221	+.009
.7262	+.010
.7304	+.009
.7353	+.008
.7401	.000
.7450	−.005
.7492	−.007
.7547	−.007
.7610	−.004
.7651	−.001
.7693	+.002
.7735	+.008
.7783	+.013
.7825	+.012
.7915	+.013
.7964	+.009
.8012	+.003
.8061	+.002
.8103	+.001
.8151	−.001
.8235	−.007
.8276	−.003
.8325	−.001
.8380	+.003

HR 6391 = 63 Her J.D.⊙	Comparison stars: HR 6455, 6480, 6499 ΔV
244 0033.7722	−.010
.7806	−.015
.7868	−.015
.7944	−.013
.8014	−.003
.8083	+.006
.8153	+.013
.8215	+.007
.8278	.000
.8340	−.001
.8431	−.005
.8514	−.011
.8604	−.012
.8667	−.016
.8771	−.015
.8875	−.016
.8944	−.015
.9007	−.003
.9083	+.008
.9167	+.014
.9236	+.014
.9292	+.018
.9382	+.003
.9458	−.010
.9521	−.009
.9583	−.004
244 0037.8514	−.007
.8563	−.006
.8611	−.002
.8653	−.006
.8694	.000
.8736	−.002
.8785	−.002

HR 6391 = 63 Her J.D.⊙	Comparison Stars: HR 6455, 6480, 6499 ΔV
244 0037.8826	+.006
.8868	+.006
.8910	+.010
.8951	+.005
.8993	+.005
.9063	+.004
.9125	−.004
.9188	−.006
.9264	−.008
.9313	−.016
.9368	−.003
.9417	−.001
.9472	+.001
.9528	+.011
.9576	+.011
.9632	+.011
.9688	+.002

HR 7222 J.D.⊙	Comparison stars: HR 7207, 7250, 7263 ΔV
243 9783.5736	+.019
.5813	+.019
.5896	+.017
.5979	+.005
.6014	.000
.6076	−.008
.6111	−.011
.6174	−.010
.6215	−.012
.6271	−.018
.6313	−.019
.6368	−.011
.6403	−.013
.6458	−.007
.6500	−.008
.6556	+.001
.6597	+.003
.6667	+.005
.6715	+.011
.6771	+.013
.6826	+.017
.6889	+.013
.6951	+.010
.7007	−.002
.7063	−.009
.7118	−.015

HR 7331 = 28 Aql J.D.⊙	Comparison stars: HR 7332, 7280 ΔV
243 9358.7448	+.004
.7504	+.003
.7559	+.003
.7622	−.005
.7657	−.006
.7705	−.010
.7740	−.014
.7775	−.018
.7830	−.021
.7893	−.022
.7941	−.022
.7976	−.023
.8011	−.025
.8059	−.025
.8094	−.021

TABLE II (*continued*)

HR 7331 = 28 Aql J.D.⊙	Comparison stars: HR 7332, 7280 ΔV
243 9358.8129	−.018
.8164	−.011
.8205	−.009
.8247	−.002
.8295	+.002
.8337	+.008
.8379	+.012
.8420	+.015
.8462	+.018
.8545	+.023
.8601	+.025
243 9366.7250	−.009
.7298	−.011
.7347	−.019
.7368	−.019
.7403	−.018
.7416	−.020
.7444	−.024
.7465	−.024
.7493	−.024
.7528	−.023
.7562	−.023
.7597	−.023
.7632	−.022
.7666	−.019
.7701	−.017
.7774	−.016
.7861	−.014
.7889	−.012
.7944	−.006
.7979	−.002
.8000	−.002
.8035	−.002
.8083	+.003
.8118	+.009
.8146	+.010
.8180	+.010
.8278	+.014
.8312	+.015
.8347	+.018
.8479	+.012
.8521	+.007
.9024	−.024
243 9369.6789	+.016
.6817	+.014
.6831	+.016
.6845	+.015
.6859	+.011
.6887	+.002
.6901	+.003
.6908	.000
.6928	−.001
.6956	−.001
.6977	−.007
.6998	−.009
.7026	−.008
.7045	−.012
.7067	−.016
.7116	−.021
.7137	−.028
.7192	−.028
.7206	−.031
.7220	−.033
.7248	−.032
.7262	−.035
.7276	−.033
.7289	−.033
.7303	−.031
.7331	−.027

HR 7331 = 28 Aql J.D.⊙	Comparison stars: HR 7332, 7280 ΔV
243 9369.7373	−.024
.7456	−.025
.7477	−.027
.7522	−.026
.7574	−.018
.7581	−.020
.7595	−.010
.7644	−.007
.7664	.000
.7692	+.006
.7706	+.005
.7783	+.010
.7803	+.006
.7817	+.007
.7831	+.009
.7859	+.014
.7873	+.014
.7887	+.011
.7894	+.012
.7921	+.017
.7942	+.017
.7949	+.016
.7963	+.022
.7970	+.019
.7977	+.019
.7991	+.020
.8005	+.027
.8033	+.021
.8046	+.030
.8060	+.026
.8067	+.029
.8081	+.025
.8109	+.029
.8130	+.031
.8137	+.027
.8144	+.022
.8151	+.031
.8164	+.034
.8192	+.022
.8206	+.014
.8220	+.016
.8227	+.016
.8241	+.016
.8262	+.021
.8283	+.015
.8296	+.014
.8303	+.021
.8317	+.019
.8345	+.013
.8359	+.013
.8395	+.009
.8456	+.003
.8491	−.004
.8512	−.005
.8526	−.010
.8533	−.014
.8546	−.015
.8588	−.026
.8602	−.027
.8616	−.026
.8630	−.025
.8671	−.037
.8692	−.037
243 9373.6510	−.006
.6579	−.017
.6628	−.016
.6662	−.013
.6760	−.007
.6794	−.007
.6815	−.007

HR 7331 = 28 Aql J.D.⊙	Comparison stars: HR 7332, 7280 ΔV
243 9373.6822	−.006
.6850	−.005
.6878	−.001
.6919	+.003
.6934	+.007
.7003	+.011
.7037	+.014
.7072	+.016
.7174	+.010
.7308	+.010
.7357	+.013
.7551	−.007
.7593	−.007
.7801	−.028
.7836	−.028
.8037	−.019

HR 7501 J.D.⊙	Comparison stars: HR 7502, 7505, 7533 ΔV
243 9683.7910	−.001
.7980	+.001
.8042	+.002
.8104	+.003
.8200	+.008
.8278	+.013
.8313	+.010
.8375	+.005
.8577	−.010
.8639	−.008
.8708	−.006
.8788	−.003
.8913	+.003
.9014	+.007
.9091	+.008
.9215	+.002
.9250	+.000
.9305	.000
.9368	−.004
.9431	−.007
.9493	−.004
.9563	−.010
.9618	−.002
.9659	−.006
.9729	−.005
.9799	−.001
.9819	+.005
.9902	+.011
243 9740.658	+.002
.665	+.001
.674	+.003
.676	+.006
.679	+.004
.684	.000
.687	−.002
.694	−.002
.704	+.002
.708	−.001
.716	−.001
.719	−.003
.726	−.001
.729	−.001
.738	−.004
.741	−.001
.750	+.002
.761	+.007
.768	+.004

TABLE II (*continued*)

HR 7501 J.D.⊙	Comparison stars: HR 7502, 7505, 7533 ΔV
243 9752.632	−.004
.647	−.002
.652	−.001
.669	+.001
.690	+.009
.699	+.002
.709	+.003
.713	.000
.723	−.004
.738	−.003
.749	−.005
.759	−.004
244 0031.8403	+.005
.8479	+.009
.8549	+.002
.8597	−.007
.8639	−.008
.8743	−.008
.8889	−.003
.8993	.000
.9056	+.003
.9118	+.008
.9201	+.007
.9264	+.002
.9312	+.003
.9354	−.001
.9389	−.004
.9437	−.010
.9479	−.011
.9521	−.004
.9590	−.001
.9660	.000
.9722	+.004

HR 7563 J.D.⊙	Comparison stars: HR 7401, 7420, 7545 ΔV
243 9287.8432	+.021
.8557	+.017
.8661	+.011
.8765	+.018
.8856	+.024
.9001	+.007
.9189	−.014
.9314	−.026
.9453	−.032
.9592	−.020
243 9288.8375	+.025*
.8465	+.030*
.8556	+.028*
.8688	+.020*
.8833	+.017*
.9229	+.032*
243 9289.8446	−.028
.8536	−.019
.8592	−.011
.8696	−.009
.8786	+.008
.8918	+.024
.8995	+.018
.9140	+.007
.9300	−.008
.9425	−.005
.9550	−.004
.9661	+.010
.9758	+.018
.9800	+.014

HR 7563 J.D.⊙	Comparison stars: HR 7401, 7420, 7545 V	$(B-V)$	$(U-B)$
243 9321.7104	6.348	.301	.070
.7215	.349	.295	.072
.7250	.349	.295	.075
.7319	.346	.292	.071
.7396	.331	.296	.072
.7479	.326	.290	.072
.7569	.321	.286	.069
.7604	.321	.285	.071
.7639	.320	.291	.064
.7715	.326	.287	.073
.7750	.327	.288	.075
.7785	.326	.294	.077
.7854	.332	.296	.077
.7889	.335	.301	.076
.7931	.339	.296	.072
.8007	.342	.299	.077
.8042	.341	.305	.067
.8076	.349	.302	.069
.8146	.353	.299	.070
.8236	.343	.302	.072
.8333	.342	.306	.069
.8441	.334	.302	.061
.8574	.333	.303	.062
.8604	.331	.297	.069
.8639	.324	.294	.070
.8674	.323	.294	.068
.8771	.332	.291	.071
.8840	.333	.288	.077
.8917	.327	.296	.077
.8951	.336	.292	.081
.8993	.345	.297	.076
.9063	.342	.299	.070
.9097	.343	.296	.070
.9125	.349	.299	.072
.9201	.350	.301	.065
.9236	.344	.300	.065
.9271	.339	.295	.069
.9361	.322	.299	.065

HR 7563 J.D.⊙	Comparison stars: 7401, 7420, 7545 V	$(B-V)$
243 9321.9389	6.321	.297
.9417	.315	.294
.9514	.302	.293
.9549	.295	.292
.9583	.294	.295
.9688	.293	.290
.9722	.293	
.9750	.296	
.9847	.309	
.9889	6.312	
243 9339.7111	6.348	+.301
.7208	.352	.295
.7250	.348	.295
.7319	.344	.292
.7396	.330	.296
.7479	.325	.290
.7569	.320	.286
.7604	.321	.285
.7639	.320	.291
.7715	.326	.287
.7743	.327	.288
.7771	.326	.294
.7847	.331	.301
.7889	.335	.301
.7931	.339	.296
.8000	.343	.299
.8042	.345	.305
.8146	.353	.300
.8236	.339	.302
.8333	.341	.306

HR 7563 J.D.⊙	Comparison stars: 7401, 7420, 7545 V	$(B-V)$
243 9339.8431	6.330	+.299
.8458	.327	.305
.8500	.325	.303
.8597	.322	.297
.8639	.320	.294
.8667	.319	.294
.8750	.332	.290
.8792	.332	.291
.8882	.332	.288
.8958	.338	.293
.9000	.338	.297
.9063	.341	.298
.9097	.344	.296
.9125	.349	.299
.9208	.352	.296
.9236	.346	.300
.9278	.361	.296
.9347	.327	.301
.9389	.326	.298
.9514	.321	.295
.9542	.318	.292
.9583	.218	.295
.9681	.315	.290
.9722	.317	
.9771	.321	
.9847	.330	
.9889	.332	

HR 8006 J.D.⊙	Comparison stars: HR 8054, 8095 ΔV
243 9351.7721	−.002
.7763	−.009
.7888	−.002
.7936	−.004
.8034	+.005
.8089	+.013
.8150	+.005
.8180	.000
.8228	+.001
.8270	−.006
.8353	−.020
.8520	−.011
.8617	+.003
.8673	+.008
.8728	+.001
.8770	−.011
.8818	−.014
.8902	−.011
.8943	−.007
.8992	+.002
243 9376.7131	+.010
.7166	+.002
.7193	+.002
.7214	+.004
.7242	+.005
.7381	−.007
.7436	−.009
.7464	−.009
.7492	−.006
.7520	−.002
.7541	.000
.7582	+.003
.7610	+.006
.7631	+.008
.7659	+.010
.7679	+.010
.7686	+.012
.7707	+.016
.7735	+.017
.7756	+.019

TABLE II (*continued*)

HR 8006 J.D.⊙	Comparison stars: HR 8054, 8095 ΔV
243 9376.7784	+.018
.7811	+.018
.7839	+.020
.7877	+.015
.7916	+.015
.7936	+.001
.7943	+.002
.7971	+.001
.7978	+.001
.8006	.000
.8027	−.003
.8048	−.002
.8075	−.003
.8152	−.004
.8179	−.006
.8200	−.001
.8221	+.007
.8249	+.011
.8277	+.014
.8285	+.010
.8325	+.019
.8360	+.014

HR 8006 J.D.⊙	Comparison stars: HR 8054, 8095 ΔV
243 9376.8409	+.020
.8436	+.015
.8479	+.010

HR 8584 J.D.⊙	Comparison stars: HR 8574, 8641 ΔV
243 9782.6131	−.001
.6194	−.004
.6278	−.008
.6326	−.009
.6368	−.010
.6403	−.009
.6444	−.007
.6479	−.006
.6514	−.002
.6563	−.001
.6597	+.005
.6632	+.006

HR 8584 J.D.⊙	Comparison stars: HR 8574, 8641 ΔV
243 9782.6694	+.007
.6757	+.001
.6813	−.004
.6868	−.009
.6910	−.010
.6972	−.007
.7035	.000
.7076	+.003
.7111	+.004
.7146	+.007
.7188	+.005
.7229	+.009
.7264	+.007
.7299	−.001
.7333	−.001
.7368	−.002
.7410	−.006
.7444	−.008
.7479	−.008
.7521	−.006
.7563	+.002

* Plus a small undetermined constant.

velocity variations caused by orbital motion may be much larger. It is interesting to note that whereas Abt listed the velocity of the variable ϵ Cep (=HR 8494) as constant, his radial-velocity measurements are of sufficient accuracy to define a velocity curve with an amplitude of 5 km/sec once the period of light variations is applied. This is shown in Fig. 8.

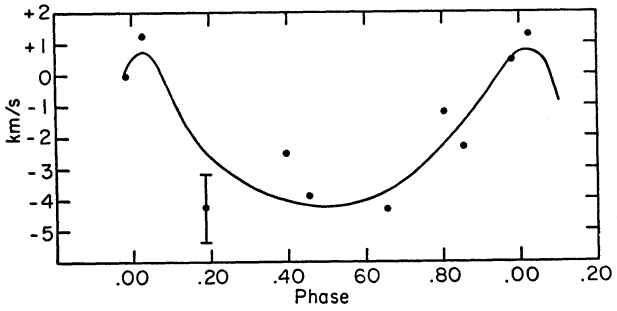

FIG. 8. Mean velocity curve of HR 8494 using measurements by Abt (1965) on 13 August 1959: A period of 0.042 days derived from light variations is used. Each circle represents the mean of two observations, while the error bar corresponds to the mean probable error of each point. The solid curve is drawn free hand.

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