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AN ANALYSIS OF RADIAL-VELOCITY MEASURES OF EIGHT STARS FORMERLY ASSIGNED TO THE BETA CEPHEI GROUP*

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ABSTRACT

Eight stars which have been suspected of belonging to the β Cephei group (namely, κ Cas, η Aur, 114 Tau, σ Ori, 10 Mon, 42 Cam, Alcor, and η Lyr) have been investigated for radial-velocity variations, using new observations with this observatory's one-prism spectrograph. By means of a statistical analysis of the data, it has been shown that none of these stars has very rapid velocity variations and that only three, namely, κ Cas, η Lyr, and (probably) Alcor, have any variations detectable with the spectrograph used. Thus most of the evidence supporting their inclusion in the β Cephei group is removed.

INTRODUCTION

This report concerns the radial velocities of eight stars, seven of which have been assigned by Payne-Gaposchkin and Gaposchkin[1] to the β Cephei (β Canis Majoris)[2] group and the eighth of which (κ Cas) has been suspected of short-period (of the order of hours) variations in velocity characteristic of the β Cephei group. Most of these stars have been placed in the β Cephei group on the evidence of radial-velocity variations with possible short periods, but this evidence is in no case conclusive. It was desired, therefore, to reinvestigate the velocities with greater care if possible. The stars referred to are the following:

κ Cas, HD 2905, type B0skea, vis. mag. 4.2.—Several investigators have found small range variations in velocity. Henroteau and Henderson[3] suggested the possibility of a short period. The lines are good.

η Aur, HD 32630, type B3, vis. mag. 3.3.—Henroteau[4] suspected short-period velocity variations which other observers have not confirmed. Guthnick and Pavel[5] suspected short-period light-variations. The lines are poor.

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[1] *Variable Stars* (Harvard Obs. Mono., No. 5 [Cambridge, Mass: The Observatory, 1938]).

[2] Struve and Swings (*Ap. J.*, **94**, 99, 1941) give good reasons for preferring the designation "β Cephei group" to "β Canis Majoris group."

[3] *Pub. Dom. Obs., Ottawa*, **5**, 1, 1921.

[4] *Pub. Dom. Obs., Ottawa*, **5**, 47, 1921.

[5] *A.N.*, **215**, 396, 1932.

114 Tau, HD 35708, type B3sk, vis. mag. 4.8.—Henroteau[4] states that the velocity is variable, but other observers have assigned constant velocity. The lines are good.

σ Ori, HD 37468, type B0k, vis. mag. 3.8.—The velocity is considered variable, the range small. Henroteau[6] has suggested that the period is short. The lines are poor.

10 Mon, HD 45546, type B3, vis. mag. 5.0.—Henroteau[6] states that the velocity is variable and the period is short, and he suspects variations in line width. The lines are poor.

42 Cam, HD 48879, type B3, vis. mag. 5.1.—The variability of velocity is regarded as doubtful, but Edwards[7] has reported line-intensity variations with period 0.1385 day. The lines are fair.

Alcor, HD 116842, type A1n, vis. mag. 3.8.—Very slight variations in light have been reported by Guthnick and Prager.[8] The velocity is regarded as variable, and rapid variations and duplicities have been reported by Frost.[9] The lines are notoriously poor.

η Lyr, HD 180163, type B5s, vis. mag. 4.4.—There is disagreement as regards variability of velocity, and Henroteau[6] suspected a short period. The lines are good.

THE OBSERVATIONS

The observations discussed in this report consisted of spectrograms of these stars, several dozen for each star, taken over the period 1939–1948 with this observatory's one-prism spectrograph fitted with the 25-inch camera lens, which gives a dispersion of 33 A/mm at $H\gamma$. Since most of the stars have lines of poor quality, Eastman Process plates were used whenever feasible, for greater contrast. Also, since rapid velocity variations were being sought, series of spectrograms over periods of several hours on single nights were made, especially for those stars for which velocity variations were actually confirmed.

When the spectrograms had been measured, it was clear that the variations in velocity, if any, were so small compared with the errors of observation and measurement that mere inspection of the velocities would lead to no useful conclusions. Schlesinger's method[10] of detecting small variations by inspecting the frequency-curve of the measured velocities was tried but was not found useful for these data. Finally, a statistical method involving analysis of variances was adapted to the purpose of detecting real variation and obtaining a measure of it. This method proved successful, and, since it may find other uses in radial-velocity work, it will now be described.

METHOD OF ANALYSIS

The kind of problem of which this is an example is familiar in statistics and is well treated by Snedecor.[11] The particular problem may be described as follows:

Suppose we have n spectrograms, on the ith of which we measure N_i lines, each line providing a value, v_{ij}, of the radial velocity. The values of $v_{i1}, v_{i2}, \ldots, v_{iN_i}$ may be regarded as a random sample of N_i individuals from a population with mean μ_i and variance σ_i^2. This population is a hypothetical one, consisting of all the velocities resulting from measurements of lines of all spectrograms made at this time under identical instrumental conditions. Individual velocities v_{ij} differ from μ_i only because of errors in measurement. We assume that these errors are essentially the same, so that $\sigma_i^2 = \sigma^2$ for all values of i; but, because of real variations of velocity or because of differing instrumental conditions, we do not assume that μ_i is the same for all values of i.

[6] *Pub. Dom. Obs.*, Ottawa, **5**, 333, 1921.

[7] *M.N.*, **93**, 729, 1933.

[8] *Veröff. U. Sternw. Berlin-Babelsberg*, **2**, 117, 1918.

[9] *A.N.*, **177**, 172, 1908.

[10] *Ap. J.*, **41**, 162, 1915.

[11] *Statistical Methods* (Ames: Iowa State College Press, 1946), chap. x.

The n means, μ_i, if they were known, would form a random sample from a hypothetical population with mean μ and variance σ_m^2. An individual μ_i may differ from the mean for one or both of two reasons: (*a*) because of varying instrumental conditions or (*b*) because of real variations of velocity. If there is such variation of either kind, then σ_m^2 is a measure of the dispersion of μ_i about μ; if there is no such variation, then the true value of σ_m^2 is zero.

Given an array of velocities for a star, such as v_{12} etc., described above, it is desired, first, to determine whether the array warrants a statement that variations in μ_i exist; second, if so, to judge whether this is instrumental or real; and, third, to form some estimate of the variance σ_m^2.

It can be shown that an unbiased estimate of σ^2 is given by

$$s_1^2 = \frac{S_1}{N-n},$$

where N is the total number of lines measured on all spectrograms and S_1 is the sum of the squares of the deviations of all the individual velocities from the appropriate "spectrogram means." Also, it can be shown that an unbiased estimate of $\sigma^2 + N_0\sigma_m^2$ is given by

$$s_2^2 = \frac{S_2}{n-1},$$

where S_2 is the sum of the squares of the deviations of the "spectrogram means" from the over-all mean and N_0 is a special average number of lines per spectrogram, given by

$$N_0 = \frac{N^2 - \Sigma N_i^2}{N(n-1)}.$$

Assuming that the variance of the means arises from random sampling (in our case that there is no real spectrogram-to-spectrogram variation), then the "ratio of the variances," namely, s_2^2/s_1^2, will assume a chance value; there is a probability, p, that it will have a value, F or better. The distribution of F according to p is known and has been worked out and tabulated by Snedecor. The so-called "Snedecor's F table" lists the numerical values of F corresponding to values of p equal to 1 and 5 per cent for various values of n_1 (our $n-1$) and n_2 (our $N-n$). These F values are often called the 1 and 5 per cent "points." Among statisticians it is common practice to regard 5 per cent and 1 per cent as lower limits of probability in this way: a computed value of the ratio of the variances which lies between the 1 and the 5 per cent points is said to be significant, that is, so large a value can hardly have arisen by chance; a value less than 1 per cent is said to be "highly significant," that is, so large a value can almost certainly not have arisen by chance. If the ratio of the variances comes out to be "significant" or "highly significant," then the sampling is proved to be, respectively, "probably not random" or "almost certainly not random."

Entering tables of Snedecor's F, then, permits us to judge the degree of significance to be attached to this ratio and therefore to judge whether the array of velocities indicates real or fortuitous spectrogram-to-spectrogram variations. Thus the first question is answered.

The answer to the second question as to whether the variations are instrumental or real must come from experience. If, for an appreciable proportion of the stars studied, there is no variation detected and for others there is an undisputed variation detected, then, unless average instrumental conditions are different for the two classes, it can be reasonably assumed that the variations detected are real and that instrumental variations do not contribute appreciably. Without such evidence, it would be necessary to test a number of standard-velocity stars to determine the extent of instrumental variations.

As regards the third question concerning the value assigned to σ_m^2, it can be seen that an estimate, s_m^2, of σ_m^2 is given by

$$N_0 s_m^2 = s_2^2 - s_1^2 .$$

Thus an estimate of σ_m^2 can be computed. However, the distribution of such an estimate of σ_m^2 about its true value is not known, and, accordingly, the computed s_m^2 must be regarded as an estimate for which the confidence limits are unknown. Its value in subsequent conclusion is therefore limited.

Suppose σ_m^2 could be computed with some degree of confidence and that its existence as a significant positive quantity could be attributed entirely to orbital motion with zero eccentricity. It can be shown on the basis of simple probability that an estimate of the semiamplitude is given by

$$K = \sqrt{2\sigma_m^2} .$$

This estimate of K is, of course, subject to the uncertainty involved in estimating σ_m^2.

REDUCTION OF THE DATA

Table 1 lists the spectrograms obtained with the number of lines measured and mean velocity obtained for each plate. It will be seen that the spectrograms cover a fair range of time and that for most of the stars there are runs covering several hours to test for short periods. Not shown, but used in the computations to follow, are the individual velocities from the lines.

With the complete data at hand for each star, it was desired, at first, to treat each spectrogram as an independent sample of the velocity population for that star and to test the sampling for homogeneity by means of Snedecor's F test. By a convenient method s_1^2, s_2^2, and N_0 were computed.

Upon entering Snedecor's F tables as described in the earlier section, if the ratio of the variances is appreciably greater than the 1 per cent point, then the results may be regarded as highly significant, i.e., they reveal a definite variation in velocities from spectrogram to spectrogram; if the ratio is less than the 5 per cent point, then the results may be regarded as not significant, i.e., not revealing any such variation. If the ratio is intermediate, the interpretation is not quite so positive.

Table 2 shows the results of this computation on the lines labeled "All separately" for each of the eight stars. (The reason for including HD 2019 is explained later.) It will be seen that for κ Cas and for η Lyr the computed value of the ratio of the variances is appreciably greater than the 1 per cent point for Snedecor's F; this indicates quite positively that the spectrogram-to-spectrogram variations are real and not fortuitous.

For Alcor the result is not so positive, the ratio lying between the 1 and the 5 per cent points. For the other five stars the ratio is appreciably less than the 5 per cent point, indicating that the spectrogram-to-spectrogram variations are probably fortuitous, or perhaps we should say that it fails to indicate that they are *not* fortuitous. The fact that no variations are indicated for five of the stars permits us to conclude that the variations indicated for κ Cas and η Lyr and perhaps for Alcor are intrinsic rather than instrumental; instrumental variations would be expected to affect all stars.

The value, s_m^2, of the estimates of σ_m^2 for each star showing nonsignificance is placed in brackets to indicate that it has no real meaning. It is included in the table to demonstrate its wide distribution about its true value; for, clearly, the true value of σ_m^2 for a star show-

TABLE 1

MEASURED RADIAL VELOCITIES
(JD 24+)

κ Cas

JD	Lines	Vel. (Km/Sec)
29198.590....	29	+ 3.7
.631....	24	− 0.4
29438.826....	24	+ 7.5
29450.867....	17	+ 0.8
29451.812....	23	0.0
.838....	22	− 6.9
.863....	23	+ 2.2
29454.849....	22	+ 3.7
29455.850....	29	+ 7.8
29506.732....	23	− 0.6
.750....	28	− 1.9
.769....	20	+ 4.7
.792....	25	+ 2.3
.811....	23	− 2.0
.831....	23	− 0.6
.851....	21	− 3.4
.869....	26	− 1.9
.888....	26	+ 0.2
29521.810....	23	+ 9.3
29522.783....	24	+ 8.9
29548.633....	31	− 0.1
32066.822....	29	+ 4.8
32075.784....	14	+ 1.9

η Aur

JD	Lines	Vel. (Km/Sec)
29521.899....	12	+17.3
29522.862....	12	+ 5.4
29548.812....	16	+ 9.6
32198.614....	10	+ 4.7
32204.592....	10	+10.2
.629....	13	+ 6.6
.685....	13	+ 5.8
32208.553....	13	+ 5.8
.602....	13	+ 5.8
.681....	11	+ 8.8
32219.671....	14	+ 7.7
32229.622....	11	+ 9.8
.635....	12	+ 8.1
.649....	10	+14.1
32233.644....	11	− 1.1
32256.583....	11	+ 9.5
32257.580....	9	+14.8
32267.558....	12	+ 9.2
.565....	9	+16.3

114 Tau

JD	Lines	Vel. (Km/Sec)
29521.919....	15	+14.9
29522.889....	18	+17.1
29548.853....	22	+15.4

114 Tau—(*Cont.*)

JD	Lines	Vel. (Km/Sec)
32204.618....	13	+16.6
.672....	15	+13.5
.698....	12	+11.0
32208.567....	15	+15.0
.617....	14	+14.5
.694....	15	+17.7
32219.690....	13	+14.2
32229.665....	8	+11.8
.671....	10	+12.8
32233.624....	14	+10.6
32253.603....	2	+15.5
32256.615....	14	+18.1
32257.602....	15	+14.3

σ Ori

JD	Lines	Vel. (Km/Sec)
29522.921....	7	+32.4
32208.636....	8	+24.7
32219.552....	8	+24.3
32229.535....	12	+27.7
.556....	8	+35.7
.578....	10	+28.8
32233.520....	11	+37.2
.558....	12	+38.7
32257.507....	7	+27.7
32561.553....	10	+38.2
.558....	10	+28.7
.562....	7	+32.2
32604.503....	10	+24.2
.507....	9	+28.7
.510....	11	+21.8
.531....	9	+27.1
.535....	9	+21.1
.538....	12	+18.1
.558....	10	+30.2
.562....	10	+29.4
.568....	12	+25.7
32605.494....	9	+39.6
.499....	10	+28.9
.503....	11	+29.9
.529....	11	+17.1
.533....	12	+28.0
.536....	10	+30.6
.556....	12	+28.8
.559....	12	+33.4
.562....	11	+25.4
32607.494....	13	+24.2
.497....	9	+34.8
.501....	11	+33.5
.549....	13	+19.3
.552....	13	+21.5
.556....	13	+28.9

10 Mon

JD	Lines	Vel. (Km/Sec)
32193.685....	9	+33.2
.691....	10	+22.4
.697....	10	+17.7
.703....	10	+24.2
.710....	10	+16.0
.716....	10	+31.7
32229.597....	9	+24.6
.604....	7	+19.6
32233.608....	9	+19.1
32256.516....	12	+31.3
32257.520....	10	+20.5
32561.574....	11	+31.1
.615....	11	+21.6
32604.522....	11	+21.3
.549....	11	+25.0
.575....	11	+27.4
32605.515....	11	+28.6
.546....	12	+27.6
.573....	11	+22.6
32607.510....	12	+22.8
.569....	11	+27.3
.578....	12	+25.8
.586....	12	+25.3

42 Cam

JD	Lines	Vel. (Km/Sec)
29549.872....	8	+ 3.3
.901....	9	+11.8
.915....	10	+16.7
.927....	11	+14.0
.937....	11	+13.2
.947....	10	+ 8.0
29612.658....	11	+ 7.5
.668....	12	+13.8
.678....	12	+ 0.7
.688....	11	+17.1
.698....	12	+10.5
.708....	13	+ 4.2
.728....	12	+ 9.0
.738....	12	+ 2.8
.786....	13	+ 4.1
.796....	13	− 2.1
.806....	12	+ 8.4
.821....	12	+ 2.3
.833....	12	+ 6.3
.844....	11	+ 6.9
29659.601....	9	+ 8.1
.612....	10	+ 8.4
.625....	10	+10.9
.637....	10	+ 9.7
.649....	9	+ 2.4
.660....	10	+10.4
.672....	10	− 1.2

TABLE 1—*Continued*

JD	Lines	Vel. (Km/Sec)
42 Cam—(*Cont.*)		
29659.682....	11	+12.6
.696....	9	+ 0.7
.708....	11	+ 9.6
.719....	10	+ 8.5
29660.569....	11	− 0.5
.594....	9	+ 3.9
.621....	11	+ 9.4
.646....	11	+ 9.6
Alcor		
29438.585....	4	−14.2
.656....	4	− 4.4
29448.602....	4	− 6.0
.686....	3	− 5.9
29451.671....	4	−13.3
29453.659....	4	−22.7
29455.639....	4	− 6.2
31991.594....	3	−10.8
31997.585....	3	− 4.6
.601....	4	− 2.8
.620....	3	− 0.9
.678....	3	+ 9.4
32007.593....	3	−12.3
.614....	3	−24.9
.640....	3	−16.7
.678....	4	+ 2.9
32011.579....	4	−12.9
.596....	3	−13.0

JD	Lines	Vel. (Km/Sec)
Alcor—(*Cont.*)		
32011.647....	4	− 6.2
.665....	4	−10.4
.685....	2	+ 1.7
32347.588....	3	−20.8
.608....	3	−37.2
.631....	4	−17.2
.653....	4	− 1.4
.674....	4	−20.0
.698....	4	− 7.3
32353.602....	4	−12.1
.631....	4	−11.7
.658....	4	− 4.3
.686....	3	− 8.0
.714....	4	− 7.9
.742....	4	−15.1
32693.588....	4	− 3.9
.606....	4	−16.6
.617....	4	− 9.6
.622....	4	+12.0
.627....	4	− 1.3
.696....	4	− 3.8
.705....	4	+14.4
.708....	4	−18.4
.714....	4	−13.1
.718....	4	−20.9
.723....	4	−17.0
.728....	4	−26.0
.732....	4	−11.8
.736....	4	− 8.6
.742....	4	− 1.9

JD	Lines	Vel. (Km/Sec)
η Lyr		
29438.689....	16	− 9.4
.793....	18	−10.5
29448.722....	20	− 6.3
29450.730....	12	− 6.5
.818....	16	− 8.5
29451.712....	18	−12.0
.743....	16	− 9.2
.776....	16	−10.7
29453.789....	18	− 8.4
29454.746....	18	− 3.2
29455.774....	19	+ 0.2
29521.562....	15	−18.0
29522.515....	15	−10.4
.665....	18	− 5.0
29548.475....	17	− 6.5
.483....	13	− 9.7
.492....	13	−11.3
.501....	14	− 7.0
.509....	13	− 7.8
.517....	13	−14.3
.526....	15	− 3.9
.535....	14	− 5.3
.543....	13	− 9.1
.552....	15	− 7.0
.562....	16	− 7.7
.569....	16	− 7.2
29549.574....	16	− 6.5
.583....	14	− 5.1

ing no velocity variation is zero. When the estimate of σ_m^2 comes out negative, it means that the agreement of the velocities from spectrogram to spectrogram is better than one could expect from the agreement from line to line on the spectrograms.

While it is true that the tests just described should reveal short-period variations as well as longer-period variations, a more specific test for short-period variations is afforded by using only the several runs on separate nights which are included in the data. Table 2 gives the results for such runs of four spectrograms or more. These results show that in no case do the velocities indicate variations over a period of a few hours.

Since the stars κ Cas, η Lyr, and probably Alcor show variations in the over-all test but none in the short-period test, it would appear that the spectrograms comprising a run or even a pair should not be treated separately but should be grouped together to form a single sample. The results of such grouping is therefore also shown in Table 2. For the other five stars the same thing has been done in order to allay any suspicion that the homogenizing effect of single-night observations has been sufficient to mask night-to-night variations.

The case of Alcor calls for special comment. All the spectrograms are on Eastman Process plates except the run of fifteen on JD 2432693, which are on the faster, more grainy, and less contrasty emulsion, Eastman 103*a*-O, which was used for the purpose of obtaining a more complete series. It will be noticed in Table 2 that the latter series gives a high value of s_1^2/N_0, which is the best estimate of the average variance of the spectrograms. That is to say, these spectrograms provide a less critical test than do the Process. It is not surprising, therefore, to find a difference in the results when they are included in the "by-nights" grouping and when they are not included. Their larger variance and their appreciable weight by virtue of their large number appears to be suf-

TABLE 2

ANALYSIS OF VARIANCE

Star	n	N	N_0	s_1^2	s_2^2	s_2^2/s_1^2	Snedecor's F 1 Per Cent	Snedecor's F 5 Per Cent	s_m^2	K (Km/Sec)
κ Cas:										
All separately	23	549	23.2	156	389	2.5	1.8	1.5	10	....
One-night runs	9	215	23.9	165	139	1.2	2.6	2.0	(− 1)	....
Grouped by nights	12	549	40.2	158	563	3.6	2.3	1.8	10	4.5
η Aur:										
All separately	19	224	11.8	129	168	1.3	2.0	1.6	(3)	....
Grouped by nights	12	224	18.2	128	216	1.7	2.3	1.8	(5)	....
114 Tau:										
All separately	16	214	13.3	66	66	1.0	2.1	1.7	(0)	....
Grouped by nights	11	214	18.8	69	71	1.0	2.4	1.9	(0)	....
σ Ori:										
All separately	36	372	10.3	513	338	0.7	1.6	1.4	(−17)	....
One-night runs	9	92	10.2	437	178	0.4	2.7	2.0	(−25)	....
	9	98	10.9	694	376	0.6	2.7	2.1	(−29)	....
	6	72	12.0	502	400	0.8	3.3	2.4	(− 8)	....
Grouped by nights	10	372	33.7	496	512	1.0	2.5	1.9	(1)	....
10 Mon:										
All separately	23	242	10.5	219	266	1.2	1.9	1.6	(4)	....
One-night runs	6	59	9.5	313	596	1.9	3.4	2.4	(28)	....
Grouped by nights	9	242	25.6	226	155	0.7	2.6	2.0	(− 3)	....
42 Cam:										
All separately	35	378	10.8	227	274	1.2	1.8	1.5	(4)	....
One-night runs	6	59	9.8	173	206	1.2	3.4	2.4	(4)	....
	14	168	11.2	221	322	1.5	2.2	1.8	(9)	....
	11	109	10.8	287	201	0.7	2.5	1.9	(− 8)	....
	4	42	10.6	275	259	1.0	4.3	2.8	(− 2)	....
Grouped by nights	4	378	86.0	229	437	1.9	3.8	2.6	(2)	....
Alcor:										
All separately	48	178	3.7	216	338	1.6	1.7	1.5	33	....
One-night runs (Process)	4	13	3.2	167	121	0.7	7.0	3.9	(−14)	....
	4	13	3.2	232	485	2.1	7.0	3.9	(79)	....
	5	17	3.4	50	94	1.9	5.4	3.3	(13)	....
	6	22	3.8	255	447	1.8	4.4	2.8	(51)	....
	6	23	3.8	68	59	0.9	4.3	2.8	(− 2)	....
One-night runs (E103*a*-O)	15	60	4.0	376	518	1.4	2.5	1.9	(36)	....
Grouped by nights (all)	12	178	13.1	243	338	1.4	2.4	1.8	(7)	....
Grouped by nights (Process)	11	118	10.3	151	359	2.4	2.5	1.9	20	6
η Lyr:										
All separately	28	443	15.8	96	215	2.2	1.8	1.5	8	....
One-night runs	12	172	14.3	124	102	0.8	2.3	1.8	(−22)	....
Grouped by nights	11	443	37.1	92	448	4.9	2.4	1.8	10	4.5
HD 2019 (binary)	18	99	5.5	128	14098	110	2.2	1.8	2549	71

ficient to mask the difference shown by the Process plates alone. However, even considering the Process plates alone in the by-nights grouping, the significance of the results is open to question, since the ratio of the variances lies between the 1 and the 5 per cent points. We perhaps should say there is a fair degree of probability that Alcor varies in velocity.

Finally, therefore, we conclude that κ Cas and η Lyr almost certainly, and Alcor probably, have velocity variations which, if periodic, have periods not of the order of hours but rather of days and that, further, assuming a circular orbit and using the relation $K = \sqrt{2\sigma_m^2}$, we estimate their semiamplitude to be of the order of 5 km/sec. The other five stars tested have no velocity variations detectable with our spectrograph.

As a check on the method of estimating the semiamplitude, the star HD 2019 was tested by this same method. This star is a spectroscopic binary recently solved by the writer from spectrograms under the same instrumental conditions as for the eight stars. The lines are poor and few (three to seven were measurable), and the probable errors for single plates were comparable with those for the eight stars. Eighteen spectrograms had

TABLE 3

MEAN D.D.O. AND ADOPTED STELLAR AND Ca^+ VELOCITIES

Star	Velocity Variable?	Stellar Velocity		Ca^+ Velocity	
		D.D.O.	Adopted	D.D.O.	Adopted
κ Cas	Var.	+ 4.4	− 4.7	−15.7	−16.4
η Aur	....	+ 8.3	+ 8.5	− 2.0	....
114 Tau	....	+14.7	+17.0	+14.8	+21.0
σ Ori	....	+28.2	+27.8	+11.8	+16.3
10 Mon	....	+24.8	+24.0	+31.2	....
42 Cam	....	+ 7.4	− 1.2	+ 0.8	Stellar
Alcor	Var.(?)	−10.2	− 2.0	Stellar	Stellar
η Lyr	Var.	− 7.7	− 8.0	−12.6	Stellar

been taken at random times before the period (3.11276 days) was determined and efforts made to "fill in" the velocity-curve.These eighteen spectrograms were chosen, therefore, as random samples of the velocities, and the same analysis was carried out as described above. The results are shown in Table 2. The estimate for σ_m^2 of 2549 gives a value of 71 km/sec for the semiamplitude, using the formula $K = \sqrt{2\sigma_m^2}$. The actual value of K computed from the binary solution, using the results of 32 plates, was 80 km/sec.

Reference has already been made to Edwards' study of intensity variations in the lines of 42 Cam.[7] The period of 0.1385 day is more than covered by one of our runs and nearly covered by another. These spectrograms are of excellent quality and uniform density. They completely fail to show any variations in line intensity or line width. Unless Edwards' results may be considered to be due to the vagaries of slitless spectrograms, this indicates a change in the character of the spectrum between 1933 and 1939.

In Table 3 the mean velocities as determined from our measures are compared with the adopted velocities quoted from Plaskett and Pearce's Catalogue[12] for the B-type stars and from Moore's Catalogue[13] for Alcor. Our mean velocities were taken, for the stars which indicated no variations, as the averages of all individual line measures and, for the three stars which did show variations, as the unweighted averages of the nightly means. Accordance with adopted velocities is good except for κ Cas and Alcor, both of which

[12] *Pub. Dom. Ap. Obs., Victoria*, **5**, 99, 1935.

[13] *Pub. Lick Obs.*, Vol. **18**, 1932.

have variable velocity, and for 42 Cam. For this last-mentioned star the velocity difference may be real and may be connected with a possible change in the character of the spectrum already referred to.

For all the stars except Alcor the Ca^+ lines have not been included in the velocity determinations; the velocities given by them are shown separately in Table 3. The character of the Ca^+ lines for η Aur and 10 Mon was not classified by Plaskett and Pearce; judging from the present results, they are probably interstellar rather than stellar.

Since this careful examination of the velocities of these eight stars gives no indication of very short-period variations and since the reported line-intensity variations for 42 Cam are not confirmed, it is concluded that these stars should not be retained in the β Cephei group.

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