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A Spectrographic Study of Early Class B Stars

Second Paper

By F. HENROTEAU, PH.D.

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A SPECTROGRAPHIC STUDY OF EARLY CLASS B STARS

SECOND PAPER

BY F. HENROTEAU, PH.D.

The present paper, in which Mr. Henderson greatly assisted, is the second of a series, and continues the work begun on class B stars and published as No. 1, Volume V of the Publications of the Dominion Observatory, Ottawa. As before, a table of the stars investigated, arranged in order of right ascension, will be given first, and then each will be considered separately.

SECOND SERIES

H.R.	Star	R. A. (1900)	Decl. (1900)	Visual Mag.	Spect.
		h m	° ′		
38	H. R. 38	0 7·6	+37 9	6·57	B3
193	o Cassiopeiæ	0 39·2	+47 44	4·70	B2
896	λ Ceti	2 54·4	+ 8 31	4·69	B5
1123	40 Persei	3 36·0	+33 39	5·04	B2
1149	20 Tauri (Maia)	3 39·9	+24 4	4·02	B5
1320	μ Tauri	4 10·1	+ 8 39	4·32	B5
1463	ν Eridani	4 31·3	− 3 33	4·12	B2
1520	μ Eridani	4 40·5	− 3 26	4·18	B5
1567	π^5 Orionis	4 49·0	+ 2 17	3·87	B3
1641	η Aurigæ	4 59·5	+41 6	3·28	B3
1810	114 Tauri	5 21·6	+21 51	4·83	B3
1843	χ Aurigæ	5 26·2	+32 7	4·88	B1
1946	126 Tauri	5 35·5	+16 29	4·87	B3
2387	4 Can. Majoris (ξ^1)	6 27·6	−23 21	4·35	B1
2511	43 Camelopardalis	6 42·9	+69 0	5·13	B5
4119	30 Sextantis	10 25·2	− 0 8	4·95	B5
4787	κ Draconis	12 29·2	+70 20	3·88	B5p
5040	64 Virginis	13 17·2	+ 5 41	5·87	B
5953	δ Scorpii	15 54·4	−22 20	2·54	B
6092	22 Herculis	16 16·7	+46 33	3·91	B5
6161	15 Draconis	16 28·2	+68 59	4·98	B8p
6396	ζ Draconis	17 8·5	+65 50	3·22	B5
6714	67 Ophiuchi	17 55·6	+ 3 56	3·92	B5p
8238	β Cephei	21 27·4	+70 7	3·32	B1
8797	1 Cassiopeiæ	23 2·4	+58 53	4·93	B

We shall now consider these stars separately.

H.R. 38 (ANDROMEDÆ)

So far as we know, no radial velocity has ever been obtained for this star. On account of its faintness, the exposure was four hours and thirty-two minutes, which gave a spectrum that should furnish a fairly reliable velocity. The exposure time required prohibits its investigation here for short period variation, but a more powerful telescope would shorten this time, and make it possible to obtain several consecutive spectrograms.

The following table gives the spectral lines found, with their widths measured in angstroms, and the radial velocities as found for them. The agreement amongst the various velocities is fairly good for a star of this type and for lines to which we attributed such small weights. The weights according to our custom are estimated on a scale of 10, 10 being the weight assigned to the very best measurable line.

CHARACTERISTICS OF LINES IN SPECTRUM OF H.R. 38 (ANDROMEDÆ)

Element	λ	Width in angstroms	Plate 8789	
			Vel.	Wt.
He	4026·352	1·8 weak	−19·1	1
Hδ	4101·890	2·2 diffuse	.....	.....
He	4143·928	1·6 diffuse	−15·5	1
C	4267·301	1·3 weak	− 6·4	1
Hγ	4340·634	1·6 weak	− 1·1	1
He	4388·100	1·6 diffuse	+22·2	2
He	4471·676	1·8 diffuse	− 7·4	3

Beyond *He* 4471, the spectrum is too weak on our plate.

The velocity obtained for the star on 1919 October 29·667 G.M.T. (middle of exposure) and corrected for the revolution and rotation of the earth is −10·5 km. ± 4·1 km.

o CASSIOPEIÆ

To our knowledge, no radial velocity has ever been found for this star. We obtained four spectrograms of it and, although the continuous spectrum is not weak and many lines seem to appear in it, it was impossible to obtain any reliable velocity. The fact is, however, that after closer examination, many of the lines, especially on our first plate, appeared to us to be double, although their great fuzziness prevents us from concluding positively. Considering this fact, the measures of line-widths would be without value.

The following lines have been identified in the spectrum:—

Element	λ
He	4026·352
Hδ	4101·890
He	4143·928
Hγ	4340·634
He	4388·100
O	4396·140
O	4465·540
He	4471·676
Hβ	4861·527

On the last three plates the double character is not so apparent as on the first one, and the lines are merely very wide. The first plate was taken on October 19, 1919, while the three others were taken on July 19, 1920. The mean velocity on this last date, considering the lines single, is of the order of −80 km.

λ CETI

The two spectra we have obtained for this star are rather poor and the velocities they furnish are far from reliable. The widths of lines and the velocities they give are found in the following table:—

LINES, THEIR WIDTHS AND VELOCITIES IN SPECTRUM OF λ CETI

Element	λ	Width angstroms	8801		8802	
			Vel.	Wt.	Vel.	Wt.
Hδ	4101·890	5·0 very diffuse	+29·8	1	.....	.....
Hγ	4340·634	4·7 very diffuse	+ 9·0	1	+18·1	1
He	4388·100	diffuse	+53·8	1	.....	.....
He	4471·676	4·9 diffuse	−31·0	1	.....	.....
Mg	4481·397	2·0	+21·2	6	+12·5	6
Hβ	4861·527	6·1 diffuse	−17·5	1	−23·8	1

This furnishes for λ Ceti the following velocities:—

Plate	Date	Velocity
		km.
8801	1919 Nov. 13·762	+11·1 ± 6·6
8802	1919 Nov. 13·832	+ 4·1 ± 6·0

To which may be added the velocity used by Dr. W. W. Campbell in his work on "The motions of the brighter class B stars," and which is +14 km. No other velocity is known to us. Campbell's velocity agrees fairly well with ours, considering the very poor quality of the spectrum.

40 PERSEI

Only very few lines were found on our spectrograms of 40 Persei; they are rather diffuse and not susceptible of accurate measurement.

The following table gives the spectral lines, their widths and the radial velocities they furnish.

Element	λ	Width angstroms	9445		9446		9447		9448	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
C	4267·301	very diffuse	+30·0	3	.....	....	.....	....	.....	....
Hγ	4340·634	3·2 diffuse	+32·8	1	+12·4	1	+45·2	2	+36·2	1
He	4388·100	3·3 diffuse	+53·8	4	+31·6	3	− 1·2	3	+ 7·0	3
He	4471·676	2·1 diffuse	− 5·0	2	+31·0	6	+33·5	5	+31·0	3
?	4609·700	diffuse	.....	....	.....	....	+15·0	2	.....	....

This furnishes for 40 Persei the following velocities:—

Plate	Date	Velocity
		km.
9445	1920 Dec. 24·576	+16·3 ± 8·4
9446	24·612	+12·8 ± 2·8
9447	24·663	+ 7·1 ± 6·5
9448	24·711	+ 4·8 ± 6·0

To which may be added the velocity given by Professor Frost (Astrophysical Journal, Vol. XXXII, 1910, p. 84), which is +3 km. Considering the large probable errors of the above values it is difficult to say whether the velocity is variable or not.

20 TAURI (MAIA)

20 Tauri is one of the brightest stars of the Pleiades, the latter forming a most interesting group and having always attracted the attention of astronomers, a great many radial velocities have been obtained for the brightest stars that compose it. Maia presents, however, greater interest than the other stars of the Pleiades on account of the fact that it is the only bright star (all the brightest stars are of class B) which shows

rather narrow and fairly well-defined lines. It is a curious fact that, the less the apparent brightness of the stars of the Pleiades, the more advanced they are in the spectral classification, the brightest being of class B, then A, then F, G, K.... and as we might suppose that all these stars are approximately at the same order of distance it is most likely that this relation exists also between absolute brightness and spectral class.

20 Tauri was announced by Adams to be a spectroscopic binary with a range of approximately 28·3 km. (Astrophysical Journal, 19, p. 341). However, a great number of plates taken at the Detroit Observatory from 1912 to 1914 and measured by Merrill seem to show that its velocity is practically constant, taking into account the large probable error of the measures.

A factor of importance which is to be considered in the study of Maia is that all the stars of the Pleiades are most likely embedded in large nebulous clouds.

In spectra of 20 Tauri taken during the same night, some have lines diffuse and hard to measure, while others seem to have these lines sharp and better defined.

The variations of aspect of lines in spectra seem to be a new factor in stellar spectroscopy; they are either periodic, such as the widening and narrowing of the lines of the stars of the β Canis Majoris type, and such as the variations of line intensities found in Cepheids; or they have apparently no period. The latter case is represented by the strengthening or weakening of bright lines, such as found by the researches of C. D. Perrine,* of R. H. Curtiss† and of others; such variations were suspected by us in the bright emission lines of the spectrum of θ^2 Orionis.

If we suppose a star in the midst of an enormous nebulosity we may suppose also waves of this nebulosity of different thicknesses or different densities passing in front of the star and altering the appearance of its spectrum. We see no reason why we should suppose a loose nebula formed of perfectly stagnant gases. On the contrary, the researches of W. W. Campbell and others on the Orion nebula (taking an example) indicate that the radial velocities at different parts of the nebula are not the same, the nebula being possibly in a state of chaotic motion.

If this should be the case for Maia, we might also expect to find, sometimes a large range of velocity and at other times a small one. In the case of β Canis Majoris (Lick Observatory, Bulletin Vol. IX) the variation of amplitude seemed to be rather erratic, although, perhaps, a long series of accurate observations might solve the question whether this variation is periodical or not. A non-periodical variation of the amplitude of the velocity curve could occur also for Maia.

* Publ. of the American Astronomical Society, 22nd meeting, p. 38.
† Detroit Observatory Publ. Vol. II.

Let us now examine, first our observations of Maia and then all the observations at present available.

Here is the detailed examination of our spectra—

CHARACTERS OF LINES FOUND IN SPECTRA OF MAIA

Element	λ angstroms	Width angstroms
?	4069·7	diffuse
Hδ	4101·890	3·1
Si	4128·211	1·3
Si	4131·047	1·3
C	4267·301	1·7
?	4294·301	1·7
Hγ	4340·634	variable from 2·4 to 4·1 ?
He	4388·100	varied from 1·8 to 4·2
He	4471·676	3·0
Mg	4481·397 on plate 8859 it seems double or rather wide with emission in centre.	strong line, but varies in widths considerably, being sometimes sharp and of width 1·1 and sometimes wide and diffuse and width 5·6.
He	4713·308	diffuse
Hβ	4861·527	wide, diffuse.

The velocities we have obtained for 20 Tauri are given in the following table; they have a large probable error and are consequently not very reliable. We also give the velocities obtained from the magnesium line Mg 4481 alone, as this line seems to furnish results which might become interesting after the securing of a greater amount of data. The velocities given by this line on our plates seem indeed to show that they fit a curve with a range of about 50 km. and a period of about 2 hours. If this is really the case, 20 Tauri would be classified as the spectroscopic binary (or pulsating star) with the shortest known period.

RADIAL VELOCITIES OF 20 TAURI OBTAINED AT OTTAWA

Plate	Date	Velocity	Veolcity given by *Mg* 4481
		km.	
8853	1919 Dec. 16·585	−13·2 ± 5·5	+11·5
8854	" ·611	+18·0 ± 8·0	+37·7
8855	" ·633	−21·4 ± 2·6	−23·6
8856	" ·655	−12·2 ± 4·4	+ 0·1
8857	" ·678	+13·4 ± 0·9	+15·1
8858	" ·718	− 4·2 ± 4·2	+ 0·1
8859	" ·776	+ 6·0 ± 3·0	+ 2·4
8860	" ·800	− 7·8 ± 7·0	−22·8
9223	1920 Aug. 16·784	+39·1 ± 2·7	+35·4
9224	" ·811	+19·0 ± 6·2	+21·5
9225	" ·834	− 7·4 ± 7·3	+ 0·4
9226	" ·855	+ 2·9 ±10·3	+16·7
9231	Aug. 17·805	+12·6 ± 1·9	+ 9·2
9232	" ·825	− 0·7 ± 4·3	+10·1
9233	" ·841	+24·2 ± 2·8	+30·4
9234	" ·855	− 8·5 ± 3·4	+ 3·0
9235	" ·868	− 8·6 ± 4·8	−18·4
9236	" ·882	− 4·7 ± 5·1	−27·1
9237	Aug. 18·793	− 5·9 ±14·6	−18·2
9238	" ·819	+ 3·0 ± 3·8	+11·7
9239	" ·842	+15·4 ± 5·4	+23·0
9240	" ·863	+31·8 ±10·2	+22·9
9241	" ·884	−19·6 ± 3·2	−15·9
9246	Aug. 20·769	+30·5one line only	+30·5
9249	" 22·801	+15·4 ± 1·6	
9250	" ·841	+20·7 ± 3·6	+20·4
9251	" ·859	+15·8 ± 5·9	+39·2

To the above may be added the following velocities which have been obtained at other observatories:—

RADIAL VELOCITIES OF 20 TAURI OBTAINED AT OTHER OBSERVATORIES

Place	Date	G. M. T.	Velocity	Remarks
			km.	
Potsdam*	1902 Feb. 16.....	·306	+ 9·5	Spectograms taken by Prof. Hartmann and measured by Dr. J. Jung in Göttingen.
	Mar. 5.....	·310	+10·2	
	" 13.....	·269	+15·2	
	1903 Jan. 13.....	·264	+ 5·5	
Yerkes†	1903 Oct. 30.....	.....	− 7·4	Adams' spectrograms.
	Dec. 25.....	.....	+20·9	
	" 27.....	.....	− 5·2	
	1904 Jan. 2.....	.....	+ 4·3	
	" 9.....	.....	+ 2·0	
	Mar. 19.....	.....	+ 8·9	
	" 25.....	.....	+ 1·8	
Ann Arbor‡	1912 Oct. 4.....	·863	+10·4	Spectrograms taken by Curtiss, Lindsay, Mellor and Merrill. All measured by Merrill.
	" 5.....	·746	+12·6	
	" 5.....	·765	+ 3·4	
	" 5.....	·800	+11·2	
	" 6.....	·750	+11·4	
	" 7.....	·864	+13·1	
	" 13.....	·793	+ 7·6	
	" 16.....	·820	+ 1·5	
	" 25.....	·860	+ 3·6	
	" 26.....	·785	+13·9	
	" 26.....	·799	+ 9·2	
	" 26.....	·809	+ 4·3	
	Nov. 3.....	·799	+ 2·3	
	" 3.....	·808	+ 9·6	
	" 10.....	·816	+ 2·1	
	" 10.....	·829	+ 0·4	
	" 15.....	·756	− 1·7	
	" 15.....	·767	− 5·6	
	" 22.....	·811	+ 4·9	
	" 27.....	·725	+ 9·9	
	" 29.....	·756	+ 7·2	
	" 29.....	·771	+ 8·4	
	" 30.....	·693	+ 2·0	
	" 30.....	·714	+ 1·0	
	Dec. 7.....	·582	+ 5·1	
	" 8.....	·632	+ 9·9	
	" 8.....	·666	+ 4·7	
	" 14.....	·697	+ 4·8	
	" 14.....	·709	+12·3	
	1913 Jan. 12.....	·718	− 2·1	
	" 12.....	·739	+ 5·0	
	" 24.....	·638	+ 8·1	
	" 24.....	·658	+12·1	
	Feb. 8.....	·619	+ 6·0	
	" 8.....	·649	+10·6	
	" 17.....	·616	+ 6·2	
	1914 Feb. 1.....	·524	+10·2	
	" 1.....	·567	+ 5·8	
	" 1.....	·597	+ 6·0	
	" 1.....	·622	+ 3·4	

* Astronomische Mitteilungen der Königlichen Sternwarte zu Göttingen XVII, 1914.
† Astroph. Journ. 19, p. 341.
‡ Publ. Univ. of Michigan, Vol. I, p. 139.

In addition some velocities have been obtained at the Lick Observatory but have not been, so far, published.

It is difficult to say now whether 20 Tauri is a spectroscopic binary or not; it seems, however, to be an interesting star worth studying with more powerful instruments.

μ TAURI

Very few velocities have been obtained before for this star. It was given by Frost* as being +27 km. and by Campbell† as +18 km. The latter is the mean of five velocities obtained at the Lick Observatory. Campbell also suspected the star to be a spectroscopic binary.

The spectrograms of μ Tauri are fairly good for measurement. We have obtained a good series of them all through the night of 1919, Dec. 5. The following table gives the spectral lines found, with their widths measured in angstroms and the radial velocities found for them on the different spectrograms.

CHARACTERISTICS OF LINES IN SPECTRUM OF μ TAURI

Element	λ	Width in angstroms	8831		8832		8833		8834		8835		8836		8837	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
He	4026·352	1·8	.....	....	+15·7	3	+19·1	2	.....	....	+13·9	4	0	1	.....	....
H*δ*	4101·890	3·9 diffuse	.....	....	+37·2	1	+ 5·6	2	.....	....	+19·5	3	.....	....	.....	....
He	4143·928	1·8	.....	....	+26·2	3	.....	....	.....	....	+ 5·8	2	−22·3	2	+17·5	1
C	4267·301	2·4	.....	....	+16·0	5	.....	....	.....	....	.....	....	.....	....	.....	....
Hγ	4340·634	3·6 diffuse	+37·3	2	+26·0	2	+15·8	3	+ 1·1	1	+14·7	6	−10·2	5	+ 7·9	3
He	4388·100	2·8	+55·0	3	+16·4	4	+24·6	4	+16·4	3	+15·2	3	− 1·2	3	+ 8·2	6
He	4471·676	3·0	+ 3·7	2	+·5·0	3	+42·2	7	+22·3	2	+ 7·4	8	+17·4	5	+ 6·2	5
Mg	4481·397	2·5	+17·5	1	+16·2	3	.....	....	+37·5	1	.....	....	.....	....	−21·2	2
Hβ	4861·527	2·9 diffuse	.....	....	.....	....	+15·9	3	.....	....	+15·9	3	+28·6	2	.....	....

* Astrophysical Journal, 32, p. 84.
† Lick Observatory Bull. No. 195.

There is a slight suspicion that the widths of the lines vary from one spectrogram to another. The radial velocities obtained from the above measures are the following:—

Plate	Date	Velocity
		km.
8831	1919 Dec. 5·555	+27·6 ± 8·0
8832	·601	+12·1 ± 1·8
8833	·644	+19·7 ± 3·8
8834	·713	+13·0 ± 4·0
8835	·743	+ 6·7 ± 1·2
8836	·776	− 3·5 ± 4·8
8837	·821	− 1·2 ± 3·3

They seem to indicate notwithstanding the large probable error, that μ Tauri is a very short period binary possibly to be classified among the stars of the β Canis Majoris type.

ν ERIDANI

The spectrum of ν Eridani is fairly good for a star of early class B; the lines are rather narrow and give velocities which are fairly concordant with one another. The star was announced to be a spectroscopic binary by Frost and Adams (Ap. J. 17, 1903, p. 151), and our observations class it definitely among the stars of the β Canis Majoris type.

The following table gives the means of the widths of the lines measured on several of our plates:—

CHARACTERS OF LINES IN THE SPECTRUM OF ν ERIDANI

Element	λ angstroms	Width angstroms
N	3919·240	1·0
C	3920·800	0·8
He	3964·875	1·3 diffuse
Hε	3970·177	2·7 very diffuse
N	3995·260	1·6
He	4009·417	1·7
He	4026·352	1·7
?	4069·700	1·2
O	4072·400	1·2
Hδ	4101·890	2·2
He	4121·016	1·3 diffuse
He	4143·928	1·7
C	4267·301	1·7
O	4319·762	weak
Hγ	4340·634	2·4
He	4388·100	1·9
He	4471·676	2·3
Mg	4481·397	2·4
Si	4552·636	1·8 weak
Si	4567·897	weak
He	4713·308	2·2
Hβ	4861·527	4·4

A rather large number of scattered observations of radial velocities of ν Eridani have been obtained at the Yerkes Observatory and a few at the Lick Observatory. Most of them are unpublished and have been kindly communicated to me by Professor E. B. Frost and Dr. W. W. Campbell. They are given in the following table.

RADIAL VELOCITIES OF ν ERIDANI OBTAINED AT OTHER OBSERVATORIES

Julian Day	Velocity	Authority
	km.	
2,415,709·734	+12	Frost and Adams (III prism)
6,053·750	+27	"
6,054·827	+18	"
6,060·710	+ 3	"
6,102·690	+12	"
6,151·583	+25	"
6·159,615	+ 9	Ichinohe (I prism)
6·458,863	+ 7	Curtis and Wilson } Lick
6,470·809	+25·5	Wilson and Moore } Lick
6,803·771	+25	Ichinohe (I prism)
7,471·950	+30	"
7,478·941	+23	"
7,515·832	+17	"
7,516·817	0	"
7,519·732	+24	"
7,891·906	+ 3	Crump (II prism)
7,946·776	0	Wilson and Plummer (Lick)
2,419,711·737	+11	Lee (I prism)
9,725·842	+21	"
9,739·840	− 3	"
9,747·687	+39	"
9,797·587	+22	"
9,804·506	+26	"
2,420,814·804	+36	Crump (I prism)
0,825·770	+20	Lemkowitz (I prism)
0,839·656	+ 3	"
0,846·681	+40	"
0,866·924	+ 5	"
0,894·663	−10	"
0,909·578	+ 8	"

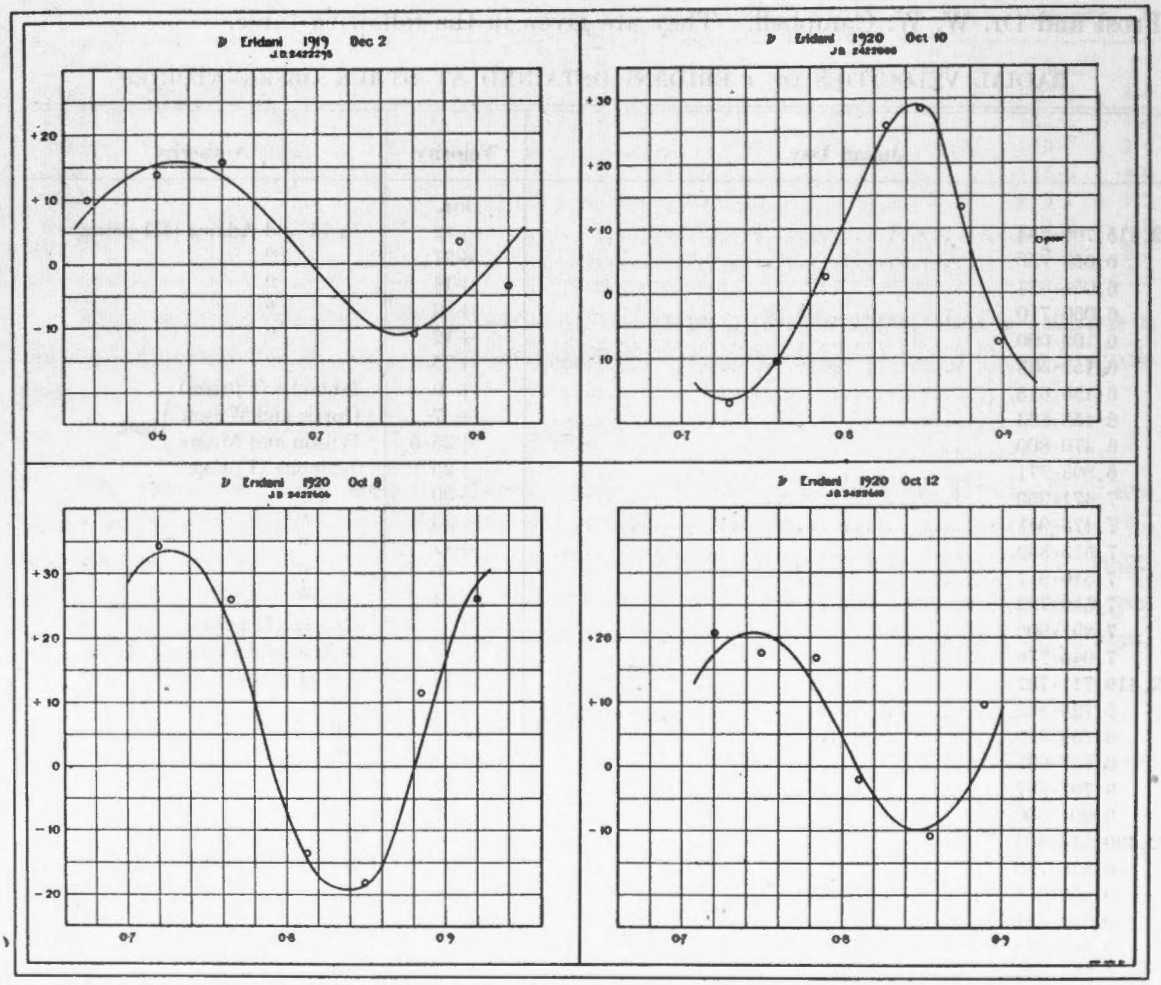
The velocities we have obtained are:—

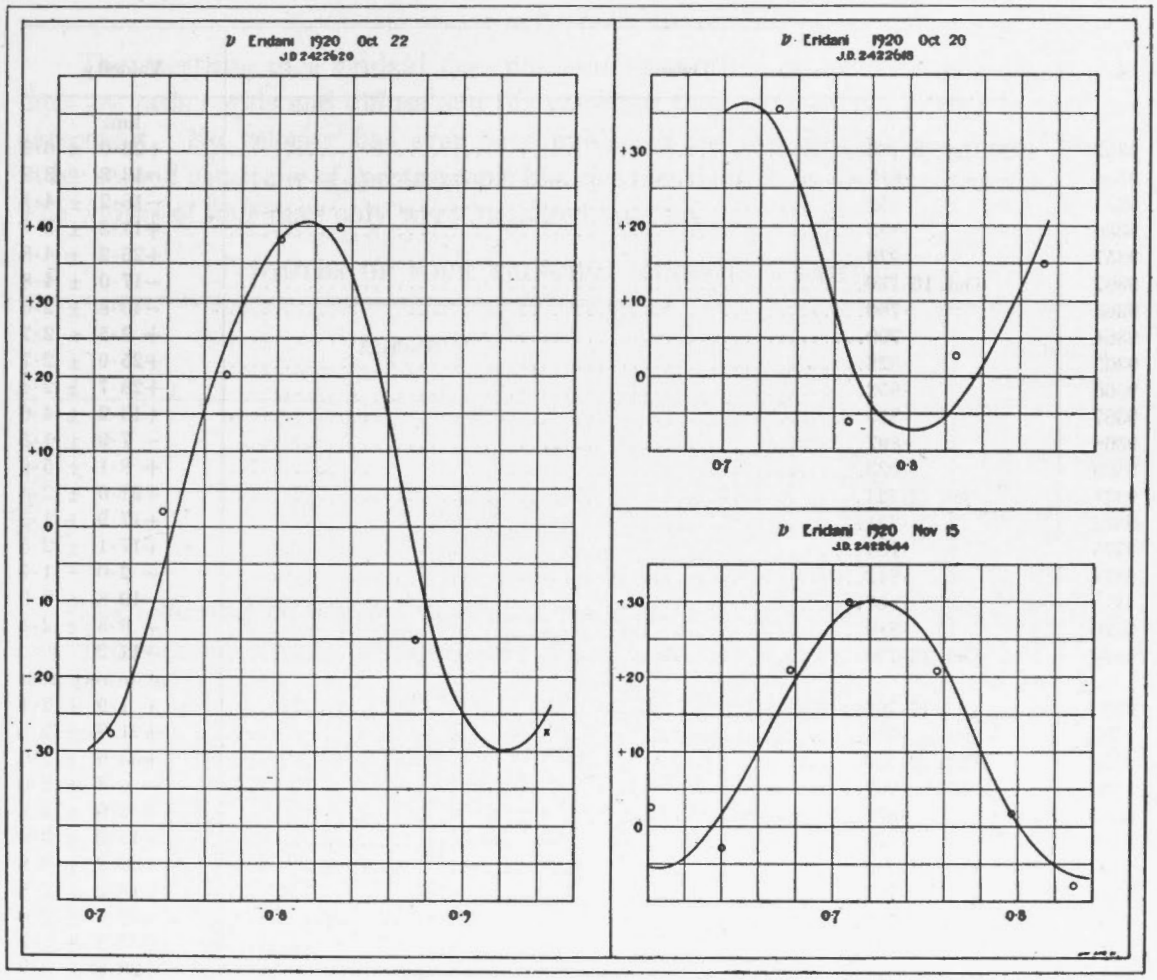
VELOCITIES OBTAINED AT THE DOMINION OBSERVATORY

Plate	Date	Velocity
		km.
8824	1919 Dec. 2·556	+ 9·6 ± 2·6
8825	·600	+13·6 ± 1·6
8826	·641	+15·5 ± 1·8
8828	·761	−11·1 ± 2·5
8829	·792	+ 3·2 ± 1·8
8830	·822	− 3·7 ± 2·0
9352	1920 Oct. 8·720	+34·4 ± 3·6

Continued on page 60

The velocities for the nights in which we have at least four of them furnish us the accompanying velocity curves.





The curves are remarkable for the large variation of amplitude which they show, the smallest amplitude found being about 26 km., while the largest is about 70 km. *No period* can connect the series of maxima (or the series of minima) indicated by these different curves; however, if we take the epoch J.D. 2422606·725 as origin and add or subtract a certain number of times the period $0^d \cdot 236672$, we obtain either a maximum or a minimum of one of the above curves, as given in the following table:—

Epochs J.D. 2422000+	
295·738	min.
606·725	max.
608·855	max.
610·748	max.
618·795	min.
620·925	min.
644·829	min.

This is a result strikingly similar to what was obtained for β Canis Majoris.*

* Lick Observatory Bulletin, Vol. IX, p. 159.

VELOCITIES OBTAINED AT THE DOMINION OBSERVATORY—*Continued from page 57*

Plate	Date	Velocity
		km.
9353	1920 Oct. 8·765	+26·0 ± 6·9
9354	·813	−13·8 ± 3·8
9355	·851	−18·2 ± 4·1
9356	·885	+11·3 ± 5·9
9357	·920	+26·2 ± 4·8
9362	Oct. 10·730	−17·0 ± 4·8
9363	·760	−10·8 ± 2·6
9364	·790	+ 2·5 ± 2·7
9365	·828	+25·9 ± 2·7
9366	·852	+28·7 ± 2·4
9367	·875	+13·2 ± 4·6
9368	·897	− 7·9 ± 1·5
9369	·923	+ 8·1 ± 5·6
9371	Oct. 12·721	+21·0 ± 2·4
9372	·751	+17·9 ± 1·5
9373	·784	+17·1 ± 2·5
9374	·812	− 2·0 ± 1·9
9375	·857	−10·8 ± 2·0
9376	·889	+ 9·8 ± 2·4
9379	Oct. 13·725	+11·2
		plate very poor
9382	Oct. 17·705	+ 1·9 ± 2·4
9383	·751	+21·7 ± 2·5
9385	Oct. 20·730	+35·6 ± 2·6
9386	·767	− 6·3 ± 2·0
9387	·826	+ 2·6 ± 2·8
9388	·872	+15·0 ± 3·9
9390	Oct. 21·747	+36·2 ± 3·8
9391	·788	+18·2 ± 2·8
9396	Oct. 22·709	−27·8 ± 2·0
9397	·738	+ 2·2 ± 2·2
9398	·773	+20·0 ± 2·7
9399	·802	+38·4 ± 2·4
9400	·834	+39·7 ± 4·6
9401	·875	−15·2 ± 3·4
9402	Oct. 23·855	+32·4 ± 1·3
9403	·895	− 8·1 ± 3·4
9418	Nov. 7·607	+24·1 ± 3·3
9419	·641	− 2·0 ± 1·7
9420	Nov.15·602	+ 2·6 ± 3·0
9421	·640	− 3·0 ± 1·7
9422	·677	+20·9 ± 1·7
9423	·708	+29·8 ± 1·8
9424	·756	+20·5 ± 3·2
9525	·796	+ 1·3 ± 2·2
9426	·828	− 8·8 ± 4·2

μ ERIDANI

The spectrum of μ Eridani does not seem susceptible of accurate measurement, the lines are rather wide and diffuse and the velocities they give are not always in very good agreement. No velocity has ever been published for this star before. Dr. Campbell in his second catalogue of spectroscopic binaries mentions it to be a spectroscopic binary. The widths of four lines only were measured, and are:

WIDTHS OF FOUR PRINCIPAL LINES IN μ ERIDANI

Element	λ	Widths in angstroms
Hγ	4340·634	4·1 very diffuse
He	4388·100	2·9
He	4471·676	4·1 very diffuse
Hβ	4861·527	5·6 very diffuse

The following table gives the radial velocities obtained from the different lines on five spectrograms secured on November 27th, 1919.

RADIAL VELOCITIES FROM THE DIFFERENT LINES

Element	λ	8813		8814		8815		8816		8817	
		Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
Hδ	4101·890	+ 4·6	1	−26·0	1	.....	....	.....	....	.....	....
C	4267·301	.....	....	.....	....	.....	....	+23·5	1	.....	....
Hγ	4340·634	−20·3	4	− 1·1	3	−30·5	2	−11·3	2	+12·4	1
He	4388·100	−72·5	2	−10·5	5	−39·8	4	−23·4	1	−31·6	1
He	4471·676	−47·1	2	−62·0	3	−49·6	2	− 6·2	4	−63·2	2
O	4591·066	−25·6	1	.....	....	.....	....	.....	....	.....	....
Hβ	4861·527	−46·1	1	−38·2	1	−25·4	1	0	1	−20·7	1

These velocities do not agree very well with each other; they furnish the following radial velocities corrected for the earth's motions:—

Plate	Date	Velocity
		km.
8813	1919 Nov. 27·653	−34·2 ± 6·9
8814	·741	−22·6 ± 7·9
8815	·770	−37·6 ± 3·2
8816	·800	− 4·7 ± 4·0
8817	·842	−32·7 ± 11·0

π^5 ORIONIS

The spectrum of π^5 Orionis is rather poor although not too bad for fairly accurate measurements. We obtained a series of eight spectrograms of it exposing almost all night of 1919, December 17th; when doing so we had no knowledge of the fact that the orbit of π^5 Orionis had been determined by Oliver J. Lee of the Yerkes Observatory.* Only three of our spectrograms have been measured and give the following results:

CHARACTERISTICS OF LINES IN SPECTRUM OF π^5 ORIONIS

Element	λ	Width of lines, angstroms	8864		8865		8866	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
He	4026·352	3·2	+ 71·3	1	.....	....	.....	....
Hδ	4101·890	2·8	+ 72·5	1	+78·1	1	.....	....
He	4143·928	2·4	.....	....	+45·6	2	.....	....
Hγ	4340·634	3·8	+ 90·4	2	.....	....	+56·5	1
He	4388·100	2·7	+ 66·7	3	+50·3	2	+58·5	2
He	4471·676	3·4	+ 99·2	3	+60·8	4	+45·0	2
Mg	4481·397	2·8	.....	....	+90·0	2	.....	....
Hβ	4861·527	4·8 diffuse	+114·5	1	+63·6	1	.....	....

They give the following velocities corrected for the sun:

Plate	J. D.	Velocity
		km.
8864	2422310·653	+77·9 ± 4·8
8865	·672	+55·7 ± 4·4
8866	·715	+45·2 ± 2·9

Taking Lee's values T=J.D. 2,417,921·640 as the epoch of maximum positive velocity of the star and Lee's period $P=3^d\cdot70045$, we obtain for T when adding to it 1286 P, T=2,422,310·374, and if we take Lee's velocity curve we see that the above values fit the curve admirably, showing that the period has not changed, seven years after Lee's last observation.

η AURIGÆ

Only two radial velocities of this star, previous to these here obtained, are known to us (Yerkes and Lick). Its spectrum offers some difficulties; the lines as in most early class B stars are very poor and sometimes furnish velocities which do not agree very well with one another.

* Astrophysical Journal, Vol. 38, 1913, p. 175.

A series of spectrograms taken on December 7th, 1919, seems to indicate very short period variation as one can see from the following detailed measures:—

WIDTHS OF LINES AND RADIAL VELOCITIES MEASURED ON SPECTRA OF η AURIGÆ

Element	λ	Width in angstroms	8838		8839		8840		8841	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
He	4026·352	2·9	.....	....	.....	....	.....	....	−38·2	1
Hδ	4101·890	3·9	.....	....	.....	....	.....	....	− 5·6	1
He	4143·928	2·5	.....	....	.....	....	.....	....	+28·1	2
Hγ	4340·634	4·2	− 1·1	1	+38·4	1	+11·3	1	− 1·1	1
He	4388·100	2·7	−21·1	3	+19·9	3	+29·2	3	−12·9	4
He	4471·676	3·0	−23·6	2	+18·6	3	+19·8	2	+29·8	3
Mg	4481·397	3·1	+23·8	2	+31·2	1	.....	....	+13·8	1

From the above measures we obtain the following velocities (corrected for the sun):—

Plate	Date	Velocity
		km.
8838	1919 Dec. 7·804	− 7·1 ± 7·7
8839	·822	+25·9 ± 2·6
8840	·839	+24·0 ± 3·2
8841	·853	+ 5·7 ± 5·7

These results seem to indicate a rapid change in velocity. Subsequent spectrograms taken in 1920 give the following results:—

Plate	Date	Velocity
		km.
9405	1920 Oct. 28·567	+ 9·4 ± 5·3
9406	·606	−24·0 ± 7·3
9408	Nov. 1·610	− 22·3 ± 6·9
9410	·696	+40·6 ± 1·9
9411	·730	+21·8 ± 5·2
9413	Nov. 3·687	+11·9 ± 7·8
9414	·754	+10·0 ± 3·3
9415	·806	− 3·1 ± 3·1
9416	·866	+ 6·0 ± 3·8
9417	·911	+21·0 ± 4·4

η Aurigæ seems to be a very short period binary, possibly of the β Canis Majoris type, but our spectrograms are too poor to decide whether it is or not. A study of the star with a better equipment than that we have at Ottawa would be advisable in order to come to a decision.

114 TAURI

The only radial velocity of 114 Tauri, known to us, is that given by W. W. Campbell in his article: "On the motion of the brighter class B Stars,"* and which is +16·5 km.

The spectrum of 114 Tauri is good for an early class B star; the lines are well defined and susceptible of accurate measurement. We only secured two spectrograms for this star in 1919, but several more in 1920.

The following table gives the means of the widths of the lines measured on our plates of 1919, together with the radial velocities they furnish:

CHARACTERISTICS OF LINES IN THE SPECTRUM OF 114 TAURI

Element	λ	Width in angstroms	8881		8882	
			Vel.	Wt.	Vel.	Wt.
He	4009·417	1·1 diffuse	−16·3	1	.....	.....
He	4121·016	0·7	−21·8	5	.....	.....
He	4143·928	1·1	−29·1	4	+ 5·8	3
C	4267·301	0·9	−30·0	4	+10·7	2
Hγ	4340·634	2·0 very diffuse	−41·8	1	+ 4·5	2
He	4388·100	1·7	−19·9	3	− 2·3	4
He	4471·676	1·3	− 3 7	2	+28·5	6
Mg	4481·397	1·0	.....	.....	+ 2·5	6
Hβ	4861·527	3·7 very diffuse	.....	.....	.....	.....

The reduced velocities of the two above plates of 114 Tauri, together with the velocities obtained in 1920 are given below.

RADIAL VELOCITIES OF 114 TAURI

Plate	Plate	Velocity
		km.
8881	1919 Dec. 19·611	−27·0 ± 2·4
8882	·684	+ 6·1 ± 3·4
9335	1920 Sept. 24·699	+35·9 ±10·7, poor plate
9337	Sept. 26·696	+28·4 ± 3·6
9338	·788	+15·3 ± 1·5
9339	·878	− 2·6 ± 8·6
9340	Sept. 28·692	+14·8 ± 2·0
9341	·825	+ 9·5 ± 3·7
9344	Oct. 6·656	+ 2·5 ± 8·4
9345	·715	+11·7 ± 4·1
9346	·764	+12·6 ± 4·2
9347	·812	+ 6·1 ± 3·1
9348	·855	+ 5·1 ± 2·8
9349	·904	− 5·7 ± 3·2

114 Tauri is thus a short period binary, possibly to be classified among the stars of the β Canis Majoris type.

* Lick Obs. Bull. No. 195.

χ AURIGÆ

The orbit of χ Aurigæ, which was discovered to be a spectroscopic binary by Frost and Adams, was determined by R. K. Young, of the Dominion Observatory.* Young finds for this orbit a period of $655^{d} \cdot 16$. The length of the period as found by Young seems to indicate a very exceptional case for an early class B star.

The spectra of χ Aurigæ are rather good and furnish fairly reliable velocities. We obtained several of them during a few nights of December, 1920. They give us the following results.

RADIAL VELOCITIES OF χ AURIGÆ

Plate	Date	Velocity
9431	1920 Dec. 7·730	−27·0 ± 4·2
9433	Dec. 8·685	−31·8 ± 3·2
9434	·729	−31·7 ± 3·7
9435	·778	−27·2 ± 2·2
9436	·835	−36·4 ± 9·4
9437	·877	−29·7 ± 2·8
9439	Dec. 17·575	− 3·0 ± 3·8
9440	·615	−26·8 ± 7·1

If we take account of Young's period of $655^{d} \cdot 16$ and take Young's orbit, we find that all the above observations except that of plate 9439 fall near the minimum of this velocity curve and verify Young's deductions. The minimum would, however, be a little lower down than that of Young, but this could be explained by the fact that Young had only very few observations to determine his minimum, as he mentions it himself in his article.

The anomalous result given by plate 9439, however, cannot be accounted for by instrumental errors, changes of temperature or such like. The measures given by different lines of this plate, as well as those of plate 9440, agree fairly well with one another, as one can see in the following tables.

DETAILED RADIAL VELOCITIES OF PLATES 9439 AND 9440

Element	λ	9439		9440	
		Vel.	Wt.	Vel.	Wt.
Hγ	4340·634	+21·5	2	−12·4	2
He	4388·100	− 4·7	3	−23·4	2
He	4471·676	0	8	−13·6	1
Mg	4481·400	−12·5	4	−63·8	1

* Pub. of the Dominion Observatory, Vol. IV, No. 1.

Already from Young's work there seems to be evidence of a short period secondary oscillation due to the possible presence of what he calls a third body. This secondary oscillation may possibly be of variable amplitude in order to give at some times large discrepancies, such as the one indicated by plate 9439 and at other times much smaller discrepancies which would pass almost unnoticed, as found in the nearly constant velocity of December 8th. χ Aurigæ thus needs to be further investigated.

126 TAURI

Dr. W. W. Campbell gives +32 km. as the radial velocity of this star,* which does not seem to have been investigated by other observers.

The lines in the spectrum are rather diffuse, but not too bad for fairly accurate measurements; the widths of some of them are given in the following table.

Element	λ	Width, angstroms
He	4143·928	2·4 diffuse
Hγ	4340·634	3·6 very diffuse
He	4388·100	2·5 diffuse
He	4471·675	2·8 diffuse
Mg	4481·397	2·2 diffuse

The plates we have obtained furnish the following velocities.

RADIAL VELOCITIES OF 126 TAURI

Plate	Date	Velocity	Remarks
		km.	
9441	1920 Dec. 23·651	−17·8 ± 6·4	6 lines measured
9442	·711	− 8·6 ± 3·0	4 lines
9443	·750	− 2·6 ± 3·7	8 lines
9444	·785	+ 0·3 ± 2·8	3 lines
9468	1921 Jan. 10·585	− 5·0 ± 6·0	6 lines
9469	·625	−22·1 ± 5·4	5 lines
9470	·660	− 8·0 ± 4·4	6 lines
9471	·705	− 7·6 ± 8·8	5 lines
9472	Jan. 12·606	− 9·2 ± 8·0	4 lines
9473	·644	−32·5 ± 8·5	2 lines
9474	·705	−20·9 ± 9·2	3 lines

On account of the large probable errors we obtain, it is very difficult to say whether the star is a short period binary or not. Compared with Campbell's velocity, however, there seems to be no doubt that the star is a binary, but probably of rather long period.

* Lick Obs. Bull. No. 195.

4 CANIS MAJORIS

This star was discovered to be a spectroscopic binary by Professor Frost.*

The lines in its spectrum are excellent, rather narrow, as one can see in the following table.

WIDTHS OF LINES IN THE SPECTRUM OF 4 CANIS MAJORIS

Element	λ	Width in angstroms
O	4079·110	1·2
Si	4089·090	1·5
He	4143·928	1·3
C	4267·301	1·4
Hγ	4340·634	2·1
He	4388·100	1·6
He	4471·676	2·6
Si	4552·636	1·4
O	4596·291	1·7
N	4601·632	1·8
Hβ	4861·527	3·1

The velocities obtained by Ichinohe at the Yerkes Observatory and given by Professor Frost are:

Date	Velocity
	km.
1905 Feb. 6·680	+37
Mar. 3·613	+32
Dec. 11·840	+22
1906 Dec. 14·730	+23

The velocities obtained by the writer are:

Plate	Date	Velocity	Remarks
		km.	
9009	1920 Mar. 1·549	+23·4 ± 3·3	15 lines measured
9011	·608	+14·5 ±12·7	3 lines (very poor)
9012	·640	+22·9 ±13·5	5 lines (very poor)
9459	1921 Jan. 3·599	−14·7 ± 2·2	9 lines
9460	·632	+ 2·0 ± 1·5	5 lines
9461	Jan. 6·594	+ 1·6 ± 4·8	5 lines
9462	·638	+35·5 ± 3·3	9 lines
9463	·719	−13·1 ± 2·6	10 lines
9464	Jan. 9·582	+29·3 ± 2·2	6 lines
9465	·635	+ 4·9 ± 1·8	9 lines
9466	·710	+10·5 ± 2·5	8 lines
9467	·750	+17·8 ± 7·3	6 lines (very poor)

* Astrophysical Journal, Vol. 25, 1907, p. 64..

The above velocities establish without any doubt that 4 Canis Majoris is a very short period binary of the β Canis Majoris type.

The study of the star, here, was rather difficult, on account of its large southern declination; the star being always near the horizon is liable to give us poor spectra, such as those of 1920, March 1st.

43 CAMELOPARDALIS

The spectrum of 43 Camelopardalis is poor; the lines are wide and diffuse and not susceptible of accurate measurement. Two spectrograms of the star were taken and the following lines were only identified in them.

Element	λ	Width in angstroms
He	4026·352	wide, diffuse
Hδ	4101·890	3·0 very diffuse
Hγ	4340·634	2·6 very diffuse
Hβ	4861·527	3·9 very diffuse

The helium line at 4471 was also visible. No velocity has been determined for 43 Camelopardalis before. The velocities we have obtained are:

Plate	Date	Velocity
9032	1920 April 6·673	−36·8
9033	·833	− 9·7

However, very little value should be attached to these velocities.

30 SEXTANTIS

Dr. Campbell gives +14 km. as the radial velocity of this star.*

The lines in the spectrum of 30 Sextantis are rather diffuse and the velocities they furnish are far from agreeing with one another.

The velocities given by the different lines are found in the following table.

* Lick Obs. Bull. No. 195.

RADIAL VELOCITIES GIVEN BY LINES OF 30 SEXTANTIS
(February 19, 1920.)

Element	λ	Width in angstroms	8989		8990		8991	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
Hδ	4101·890						−36·3	1
He	4143·928	1·0 diffuse	+ 4·8	1			+44·6	2
C	4267·301						−18·2	1
Hγ	4340·634	3·5 diffuse	−14·7	1	+30·5	2	+41·8	2
He	4388·100						−50·3	4
He	4471·676	1·1 diffuse			−27·2	2	+19·8	6
Mg	4481·397	1·5 diffuse			+13·8	2	− 7·5	8
Hβ	4861·527	5·2 very diffuse	+27·0	3	−14·3	2	+44·5	2

We are not justified in computing the mean velocity for each plate. The great differences of velocities from one line to another may, perhaps, be explained by the fact that the spectrum is composite, and that we are measuring what are really blended double lines. These lines having undoubtedly different widths, the central positions we measure would give us very different radial velocities.

κ DRACONIS

Only one radial velocity was given for this star before, by Hnatek in Vienna; it was given for 1913, April 28·403 as +17·4 km.

The spectrum of κ Draconis is very peculiar, its peculiarity having been indicated first by the Harvard observers and afterwards by Merrill in his valuable paper: "Class B stars whose spectra contain bright hydrogen lines."* We quote after Merrill: Hα bright, Hβ bright on wide absorption, Hγ, Hδ. Hε and perhaps Hζ hazily triple. Orion lines perhaps double. Moreover, on one of his plates taken at the Lick Observatory, he also mentions the fact that Hβ was double bright on absorption and Hγ hazily double bright on absorption.

Before reading Merrill's article we measured the three plates we have obtained of κ Draconis on January 18th, 1920. We noticed that Hβ was a wide emission line on a much wider absorption and that on one of the plates there might be a very faint emission in the centre of Hγ, while on the two other plates no emission was found for any other lines than Hβ. A fact that puzzled us, however, is, that the radial velocities furnished by the different lines measured are greatly discordant, sometimes showing differences larger than 100 kilometres. On one of the plates where the Orion lines are narrow, and fairly well defined, although weak, we found three lines close to one another, which may possibly be three components of the helium line at 4471. If these three components were each due to a radial displacement of gases they would furnish us the three approximate velocities of −151 km., −66 km., and +63 km. Of course, the existence of this triplet might be due to the accidental distribution of the silver particles on our plate, for a very wide absorption line. The data we have obtained from our three plates of κ Draconis are given in the following table.

* Lick Obs. Bull. Vol. 7, p. 170.

CHARACTERISTICS OF LINES IN SPECTRUM OF κ DRACONIS

Element	λ	Width in angstroms	8900		8901		8902	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
Hζ	3889·200	5·2 very diffuse	+32·7	1				
Hε	3970·177	3·5 very diffuse					+50·6	1
He	4026·352	0·5	+37·8	2				
Hδ	4101·890	2·0 very diffuse	+33·5	1	+ 6·5	1		
He	4121·016	1·0 diffuse, weak			−52·2	1		
He	4143·928	0·6 weak	−18·4	2	− 4·8	3		
Hγ	4340·634	3·3 very diffuse, with perhaps a weak emission on plate 8901.	− 9·0	1	−10·2	2	−54·2	2
He	4388·100	very weak						
He	4471·676	1·3 sharp			−151·3	3		
		0·6 "			−65·7	3		
		0·7 "			+63·2	3		
Mg	4481·397	0·8					− 5·0	5
Hβ	4661·527	Wide emission on much wider absorption.						
He	4922·10	1·2 sharp			+122·1	4		

In view of the great discordances in velocities given by the different lines, we are not justified in giving a radial velocity from each plate.

According to Professor R. H. Baker* κ Draconis has been observed at the Detroit Observatory since 1912. The spectrum resembles that of γ Cassiopeiæ. The hydrogen series consists of broad emission lines centrally superposed on broader absorption, while narrow absorption lines appear nearly central upon the emission. Broad absorption lines of helium and other elements are present. The K line is narrow. Representatives of the broad absorption and emission lines are found to oscillate in a period $8^d \cdot 986$, with a velocity range of 31 km. per second. The narrow hydrogen lines do not share the short period variation, but they change position gradually and seem to share the same variation as the so-called stationary line K, which really is not stationary, but indicates a velocity range of 12 km. in a probable period of 4 years. The narrow *Hβ*, which is frequently measured on the early plates, diminishes in width and intensity during the interval 1912–15 and thereafter is not seen. The narrow hydrogen lines would thus find their origin in the same medium as the stationary K line, perhaps in an interstellar cloud; this cloud thus would not only be formed of calcium and sodium, but also very largely of hydrogen, whose presence is detected by the fact that the narrow absorption lines are situated in the midst of wide emission lines, but which in the case of ordinary class B stars would not be detected, because in the midst of a wider stellar absorption line.

According to our spectra of January, 1920, the emission lines of κ Draconis must have weakened considerably. This does not contradict Baker's theory, however, which, I might say, is strongly supported by what we find in the spectra of novae. Our spectra of Nova Cygni No. 3 show something similar.

* Popular Astronomy, 1921, Vol. 29, p. 146.

64 VIRGINIS

This star is given under class B in the Harvard Annals, Vol. 50. However, at first sight, its spectrum which contains a certain number of metallic lines and wide hydrogen lines of the Balmer series seems to be of class A. W. S. Adams puts it in class A1. The possible existence of weak helium lines in the spectrum would indicate that the star is of class B9.

The lines in the spectrum are rather well defined and would render measured velocities fairly accurate. W. S. Adams, in his paper "The radial Velocities of Five Hundred Stars,"* gives for 64 Virginis (Boss 3462) the velocity −11·4 km. He does not give any date for it. We obtain for this star the following velocities:

Plate	Date	Velocity
8993	1920 Feb. 20·816	+11·1 ± 2·7
9014	Mar. 14·752	−15·4 ± 3·0

This star is thus a spectroscopic binary. As it is a late class B star, and also rather faint, although the spectrum is very suitable for good measurements, we did not deem studying it any further.

δ SCORPII

This star was found by Frost and Lee to be a spectroscopic binary. According to them whenever the star attains a large positive velocity, the presence of a second component is probable. The Harvard observers, Miss Maury and Miss Cannon, had already concluded that the spectrum may be composite and indicative of variable radial velocity.

The lines in the spectrum are rather wide and diffuse as can be noticed from the following table:

WIDTHS OF LINES IN SPECTRUM OF δ SCORPII

Element	λ	Width in angstroms
Hδ	4101·890	2·1 very diffuse
He	4143·928	0·7
Hγ	4340·634	1·8 diffuse
He	4388·100	1·9 diffuse
He	4471·676	3·0
Hβ	4861·527	6·3 very diffuse

*Astrophysical Journal, Vol. 17, 1915, p. 180.

We have obtained the following velocities:

OTTAWA RADIAL VELOCITIES OF δ SCORPII

Plate	Date	Velocity	Remarks
		km.	
9119	1920 May 25·610	+3·1 ± 5·9	5 lines measured
9120	·624	+4·2 ± 2·2	4 lines
9121	·669	+7·4 ± 6·7	6 lines

They indicate that the star is probably not a very short period binary. The velocities obtained at the Yerkes Observatory are:

Date	Velocity
	km.
1903 June 5·738	−25
6·691	−30
1904 Mar. 19·923	+22
1909 May 17·757	−30
June 11·707	+14

(τ) 22 HERCULIS

The spectrum of 22 or τ Herculis is fairly good. It was investigated formerly by E. B. Frost and W. S. Adams (Radial velocities of twenty stars having spectra of the Orion type).*

The following table gives the spectral lines with their widths measured in angstroms, as well as the radial velocities found for them on our plates.

CHARACTERISTICS OF LINES IN SPECTRUM OF 22 HERCULIS

Element	λ	Width in angstroms	9034		9035		9036		9037		9038	
			Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
†*Ca* (*K*)	3933·825	0·4										
Hε	3970·177	1·6 very diffuse			−17·4	4						
He	4026·352	0·8			−52·2	8	−33·1	3	−26·1	2	−27·8	2
Hδ	4101·890	1·8 diffuse			−34·4	7	−50·2	2	−23·3	2	−20·5	3
Si	4128·211	1·0 weak							−40·0	1		
He	4143·928	0·8	−28·1	2	−31·0	2	−11·6	1	−17·5	3	−36·9	1
Hγ	4340·634	1·5 diffuse	−40·7	2	−11·3	7	−30·5	5	−44·1	6	−18·1	3
He	4388·100	0·9			−43·3	2			−30·4	2	−21·1	2
He	4471·676	0·8	−34·7	4	−28·5	2	−16·1	2	−11·2	7	−36·0	6
Mg	4481·397	0·7			−28·8	3	−13·8	2	−26·2	6	−20·0	7
Hβ	4861·527	2·3 diffuse			−22·3	5	−28·6	5	−31·8	4		
He	4922·10	1·9			−42·9	1						

* Pub. of the Yerkes Obs., Vol. II, 1903, p. 230.
† Gives velocities different from those given by the other lines.

A summary of the various radial velocities found for 22 Herculis is given in the following table.

RADIAL VELOCITIES OF 22 HERCULIS

Place	Plate	Date	Velocity
			km.
Yerkes	.....	1902 Feb. 19·898	−13·5
	.....	Mar. 12·923	−11·4
	.....	13·817	−12·8
	.....	April 3·728	−13·0
Ottawa	9034	1920 April 7·714	−29·5 (3 lines only)
	9035	·783	−25·5 ± 3·1
	9036	·803	−23·3 ± 2·8
	9037	·821	−21·7 ± 2·7
	9038	·840	−20·3 ± 2·0

From these velocities, and considering the fair quality of the plates, we could not suspect a rapid variation; our velocities are, however, different from those of Frost and Adams. The star is possibly a spectroscopic binary of fairly long period.

15 DRACONIS

The spectrum of 15 Draconis deserves being called peculiar, from the fact that the hydrogen lines are exceedingly wide and diffuse, the helium lines are so diffuse that they are not measurable, while some metallic lines are fairly well defined and sharp in comparison with the others. The hydrogen lines have evidently an unsymmetrical structure as they give velocities greatly different from the metallic lines.

No velocity, to our knowledge, has ever been determined before for 15 Draconis. Our spectra, being rather poor, only a few lines have been measured on them; they are:

CHARACTERISTICS OF LINES IN SPECTRUM OF 15 DRACONIS

Element	λ	Width in angstroms	9055		9056	
			Vel.	Wt.	Vel.	Wt.
Fe	4063·756	0·3	.....	.....	+ 9·9	3
Hδ	4101·890	5·6 very diffuse	.....	.....	−20·5	2
Fe	4198·494	0·3	+15·0	2	.....	.....
Fe	4250·616	0·4	+23·1	2	.....	.....
Hγ	4340·634	5·0 diffuse	−56·5	3	− 6·8	4
Mg	4481·397	1·9	−36·2	2	.....	.....
Hβ	4861·527	8·8 very diffuse	−71·6	2	.....	.....

We would not be justified in deducing mean velocities from the above measures. The two above plates were obtained on April 13, 1920, at $15^h\ 20^m$ and at $16^h\ 23^m$ G.M.T. (middle of the exposure).

ζ DRACONIS

This is one of the stars investigated by Frost and Adams and whose velocities are given in their valuable paper: " Radial Velocities of Twenty Stars having Spectra of the Orion Type."* We cannot but confirm their description of the spectrum by saying that the lines are few in number but fairly well defined. The following table gives the spectral lines with their widths measured in angstroms, as well as the radial velocities found for them on our plates.

CHARACTERISTICS OF LINES IN SPECTRUM OF ζ DRACONIS

Element	λ	Width in angstroms	9029		9030	
			Vel.	Wt.	Vel.	Wt.
Hγ	4340·634	2·0 diffuse	−26·0	4	−29·4	4
He	4471·676	2·0 fair	.....	.....	−50·8	6
Mg	4481·397	1·2 sharp	.....	.....	−37·5	8
Hβ	4861·527	2·7 very diffuse	−28·6	4	+ 3·2	4

The velocities obtained for the different lines are in fairly good agreement. A summary of the various radial velocities obtained for ζ Draconis is given in the following table.

RADIAL VELOCITIES OF ζ DRACONIS

Place	Plate	Date	Velocity
			km.
Yerkes	.....	1902 Feb. 3·934	−14·0
		Feb. 10·925	−14·0
		Feb. 19·856	−14·0
		May 30·669	−15·7
Ottawa	9029	1920 Mar. 30·661	−27·9
	9030	·701	−32·9

Our velocities, as well as those obtained at the Yerkes Observatory, do not seem to indicate any short period variation. The change of velocity from 1902 to 1920 may be real, although we might suspect a difference of estimation of the centres of the lines (which are rather wide), a difference which would make the change of velocity only apparent, as due entirely to personal equation.

* Pubs. of the Yerkes Obs., Vol. II, 1903, p. 232.

67 OPHIUCHI

This is one of the twenty stars studied by E. B. Frost and W. S. Adams in their article "Radial Velocities of Twenty Stars having Spectra of the Orion Type."* We cannot but confirm their statement that the lines are rather diffuse in character. On some of our spectrograms they seem to be worse than on others and give velocities for the different lines which do not agree very well with one another. The widths of most of the principal lines are given in the following table.

Element	λ	Width angstroms
Si	4128·211	1·7
Si	4131·047	1·6
C	4267·301	1·3
Hγ	4340·634	2·1
He	4388·100	1·5
He	4471·676	2·1
Mg	4481·397	1·8
Hβ	4861·527	3·3

Besides the spectrograms measured by Frost and Adams a great many radial velocities have been obtained by J. B. Cannon from spectrograms taken at the Dominion Observatory. Some of the last spectrograms have been re-measured by the writer. All these velocities, together with our most recent ones, are given in the following table.

RADIAL VELOCITIES OF 67 OPHIUCHI

Author	Plate	Date	Velocity	Remarks
			km.	
Frost and Adams	.....	1902 May 14·802	− 2·7	Corrected for better λ of silicon lines.
		June 25·821	− 1·8	
		July 7·730	− 1·3	
Cannon and Henroteau	4606	1911 Oct. 2·510	+ 0·2	
	4620	" 10·494	− 1·0	
	4679	Nov. 3·496	+ 4·5	
	5060	1912 June 18·832	+ 1·3	
	5088	July 2·733	+ 2·3	
	5103	" 12·737	+ 3·4	
	5107	" 16·681	0·0	
	5116	" 19·732	+ 5·2	
	5118	" 22·615	+12·4	
	5503	1913 April 23·850	+ 7·2	
	5510	" 24·820	+ 1·9	
	5535	May 2·850	−16·1	
	5621	July 14·757	− 4·7	
	5628	" 21·739	− 3·7	
	5640	" 30·691	+ 5·5	
	5650	Aug. 18·638	−21·0	
	5667	Sept. 15·561	− 0·4	
	5676	" 19·542	− 6·2	
	5708	" 29·552	+ 0·2	

* Pubs. of the Yerkes Obs., Vol. II, 1903, p. 238.

RADIAL VELOCITIES OF 67 OPHIUCHI—*Concluded*

Author	Plate	Date	Velocity	Remarks
			km.	
Cannon and Henroteau	5731	1913 Oct. 3·528	− 0·7	
	5746	" 6·514	− 3·8	
	5773	" 13·504	+ 0·4	
	5982	1914 Mar. 16·847	− 4·5	
	5992	" 20·913	− 3·7	
	6003	" 30·880	− 4·5	
	6013	April 3·864	− 1·3	
	6020	" 6·843	− 1·4	
	6058	May 1·871	− 2·7	
	6063	" 6·730	+ 6·8	
	6074	" 14·724	− 7·2	
	6076	" 15·808	−26·2	
	6090	June 4·723	− 5·0	
	6093	" 5·732	− 6·0	
	6109	" 16·769	+ 1·2	
	6110	" 16·792	−11·5	
	6115	" 17·762	− 7·0	
	6121	" 19·715	− 5·9	
	6127	" 22·778	− 5·6	
	6135	" 26·756	− 9·7	
	6145	July 3·720	+ 2·9	
	6160	" 8·642	−13·1	
	6182	" 14·709	−21·0	
	6186	" 15·670	− 3·6	
	6191	" 16·718	−22·3	
	6196	" 17·717	− 1·8	
	6205	" 19·668	− 6·1	
	6214	" 21·660	− 7·4	
	6219	" 23·633	−20·6	
	6221	" 24·661	−15·1	
	6226	" 27·681	− 6·3	
	6235	" 30·590	− 3·7	
	8235	1917 July 24·597	− 5·5	
	8236	" 24·625	+ 0·9	
	8237	" 24·660	− 5·0	
	8238	" 24·695	− 9·4	
	8249	" 31·597	+11·9	
	8250	" 31·629	+ 4·9	
	8251	" 31·667	− 3·7	
Henroteau	9153	1920 June 24·619	−15·3 ±3·3	8 lines measured
	9154	" 24·642	− 2·1 ±2·4	4 lines
	9155	" 24·669	−19·1 ±2·2	7 lines
	9156	" 24·692	+ 7·5 ±3·3	10 lines
	9157	" 24·716	−27·9 ±6·3	4 lines (poor)
	9158	" 24·760	− 0·4 ±7·0	5 lines
	9159	" 24·782	− 4·5 ±3·7	9 lines
	9160	" 24·804	− 4·3 ±3·0	6 lines
	9161	" 24·825	−18·5 ±2·6	7 lines
	9162	" 24·845	− 1·0 ±5·3	7 lines

From all these velocities and considering the rather poor character of the lines, we are inclined to think that 67 Ophiuchi has a constant velocity, the larger velocities obtained, which are few in number, being probably due to accidental errors.

β CEPHEI

The study of β Cephei is not new, as this star has been investigated first by E. B. Frost, who found it to be a short period binary,* and then by C. C. Crump,† who presented a masterly study of it as a doctor's degree thesis in the University of Michigan. However, as the centre of mass velocity of β Cephei was suspected to vary, as well as the amplitude of the velocity curve, and although Crump took spectrograms of it in succession during whole nights, we found that the nights on which he observed it, were not very closely distributed, and we thought, recalling the motion of σ Scorpii‡, whose centre of mass revolves in an elliptic orbit in about $34^d \cdot 08$, that observations taken during whole nights which follow one another as closely as possible during the space of nearly one month, we could find results of importance. We did not find any law of variation of the centre of mass velocity, but we confirmed the variation of amplitude of the velocity curve which was detected by Crump. In the following we shall make ample use of the data obtained by Crump, as well as of ours.

Before proceeding to the study of the data we shall discuss some of the deductions made by Crump.

First, as a variation of the amplitude of the velocity curve exists, we are not fully justified in computing an orbit for the star from the mean of all the observations, as well as finding a secondary oscillation from the mean curve. It may be that this secondary oscillation exists, in which case we could only make two assumptions: the period of the primary oscillation is an exact multiple of that of the secondary, or it is not. If it is, we cannot see how this secondary oscillation would account for the variation of amplitude. If it is not, we cannot see that this oscillation could be detected in a mean curve in such a way that it would have a period of about one-third of the primary; at any moment the phases of the two oscillations would be different and they may either reinforce one another or destroy one another (entirely or partly), so that in a mean curve they would not show at all or show in a complex fashion. However, we could appeal to some other source to explain the variation of amplitude while saying that the secondary oscillation has a period exactly one-third of the primary, but in this case the very fact that the amplitude changes would destroy the regularity of the secondary oscillation as shown in plate IX of Dr. Crump's article,** especially as the observations are not distributed very evenly.

It is indeed interesting to consider β Cephei as a variable of the δ Cephei type, such as was done by Professor Guthnick, of the Berlin-Babelsberg observatory, but as it does not possess all the characteristics generally attributed to Cepheid variables, we are not justified in classifying it so. No doubt there is some resemblance and possibly a similar cause, but the data are too scant as yet to derive any conclusion.

* Ap. J., Vol. 24, 1906, p. 259.
† Detroit Obs. Pubs., Vol. II, p. 144.
‡ Lick Observatory Bulletin, Vol. 9, p. 173.
** Detroit Obs. Pubs., Vol. II, p. 154.

The following is a table of lines found in our spectra of β Cephei, together with their widths. It may be well for the reader to compare them with the widths of lines found in other early class B stars, in order to judge for himself of the quality of the spectrum. It is also likely that the widths of the lines vary, such as was found for β Canis Majoris and σ Scorpii, but our data are too poor to confirm this.

LINES AND THEIR WIDTHS IN A SPECTRUM OF β CEPHEI

Element	λ	Width in angstroms
Hε	3970·177	0·9 diffuse
He	4026·352	0·9 diffuse
Si	4089·090	0·8 diffuse
Hδ	4101·890	1·3 very diffuse
He	4121·016	0·9
He	4143·928	0·8
Hγ	4340·634	3·6 very diffuse
He	4388·100	1·8 diffuse
He	4471·676	1·8 diffuse
Si	4567·897	1·5 diffuse
C	4650·925	1·5
Hβ	4861·527	3·4 diffuse
He	4922·10	1·8 diffuse

We shall now give a table of all the radial velocities which, to our knowledge, have been published before and also have been obtained by us at Ottawa.

RADIAL VELOCITIES OF β CEPHEI

Place	Authors	Date	Julian Day	Velocity	Remarks
				km.	
Yerkes*	Frost and Adams	1901 Dec. 18		− 5·2	Fraction of day not given.
	"	1902 Jan. 8		− 9·1	
	"	Mar. 13		+ 4·3	
	"	" 26		−15·1	
	"	April 2		−19·3	
	"	" 16		+10·1	
	"	" 23		− 0·8	
	"	May 14		− 2·2	
	"	" 14		−16·3	
	"	" 16		+ 6·4	
	"	" 23		−16·8	
Lick	Curtis	1903 Sept. 16	2416374·875	− 5·9	Kindly communicated by Dr. Campbell.
	"	1903 " 20	6378·962	− 4·2	
Series of observations made by Frost in 1903, 1904, 1905, 1906 and 1912, but none of them published. Only a velocity curve published in Ap. J. 1906, Vol. 24, p. 260.					
Ann Arbor†	Crump		2419638·758	−21·1	One prism
			641·785	−19·6	
			·832	− 0·3	
			·845	− 2·5	

* Ap. J. 15, p. 340.
† Detroit Obs. Pubs., Vol. II, p. 147.

RADIAL VELOCITIES OF β CEPHEI—*Continued.*

Place	Author	Date	Julian Day	Velocity	Remarks
				km.	
Ann Arbor—*Con.*	Crump.....	.....	2419641·860	+ 2·8	
			642·698	−27·9	
			644·644	−23·6	
			·653	−27·7	
			·662	−22·0	
			·680	−11·6	
			·690	− 5·6	
			·700	− 1·4	
			·712	− 0·5	
			·724	− 2·1	
			677·565	−36·3	
			·574	−34·7	
			·583	−34·2	
			·592	−29·9	
			·600	−25·9	
			·609	−16·5	
			·616	−16·5	
			·625	− 9·4	
			·632	−10·8	
			·641	− 3·4	
			·649	+ 3·1	
			·656	+ 5·6	
			·664	+ 9·5	
			·672	+ 9·9	
			·677	+10·1	
			·688	− 0·4	
			·697	− 8·7	
			·705	− 7·2	
			·713	−16·1	
			·721	−11·7	
			·728	−16·4	
			·736	−21·3	
			·744	−27·3	
			·752	−32·8	
			·760	−28·6	
			·770	−23·4	
			·780	−23·6	
			691·558	+ 5·1	
			·564	+ 0·6	
			·571	− 0·5	
			·580	+ 5·5	
			·588	− 2·3	
			·596	− 2·2	
			·602	− 0·1	
			·607	− 5·4	
			·612	− 8·8	
			·619	−15·4	
			·630	−22·1	
			·635	−17·7	
			·639	−24·0	
			·643	−32·5	
			·648	−33·5	
			·652	−32·2	

RADIAL VELOCITIES OF β CEPHEI—*Continued*

Place	Author	Date	Julian Day	Velocity	Remarks
				km:	
Ann Arbor—*Con.*	Crump		2419691·656	−29·2	
			·660	−27·2	
			·665	−23·3	
			·669	−33·5	
			·675	−25·2	
			·679	−36·8	
			·686	−20·2	
			693·696	− 8·6	
			·706	− 3·8	
			·715	−13·1	
			·724	−11·6	
			·733	−18·3	
			·742	−28·2	
			·751	−28·7	
			·761	−28·7	
			·770	−20·7	
			·779	−29·4	
			·788	−21·6	
			·797	−14·4	
			700·611	−29·2	
			·623	−29·3	
			·634	−26·5	
			·641	−24·4	
			·648	−21·2	
			·656	−23·9	
			·659	−16·3	
			·665	−10·9	
			·670	−11·2	
			·675	−10·1	
			·679	− 3·0	
			·683	−10·8	
			·687	− 5·3	
			·697	+ 3·3	
			·701	− 4·8	
			·705	+ 2·4	
			·710	+ 0·7	
			·716	− 0·8	
			·721	+ 1·7	
			·726	+ 4·1	
			·730	− 7·2	
			·734	− 3·1	
			·738	− 7·2	
			·743	− 4·5	
			·748	−11·0	
			·757	− 8·0	
			·762	−19·2	
			·767	− 8·7	
			·775	−22·1	
			·780	−29·3	
			·794	−30·6	
			·798	−24·1	
			·803	−27·5	
			·807	−27·6	
			714·544	−28·5	

RADIAL VELOCITIES OF β CEPHEI—*Continued*

Place	Author	Date	Julian Day	Velocity	Remarks
				km.	
Ann Arbor—*Con.*	Crump		2419714·553	−24·7	
			·558	−20·8	
			·563	−24·8	
			·568	−19·9	
			·573	−18·1	
			·579	−15·1	
			·584	− 5·3	
			·590	−11·4	
			·594	− 1·0	
			·600	− 4·2	
			·604	− 2·3	
			·610	+ 5·0	
			·615	− 1·7	
			·625	+ 0·7	
			·630	− 3·6	
			·640	− 5·6	
			·645	− 5·1	
			·650	−10·7	
			·655	−14·2	
			·660	−17·2	
			·665	−14·0	
			·670	−21·0	
			·675	−23·2	
			·686	−24·7	
			·692	−28·5	
			·698	−25·7	
			·703	−27·8	
			·708	−35·2	
			·713	−32·4	
			·718	−31·6	
			·723	−27·1	
			·728	−22·9	
			·734	−28·6	
			·738	−21·1	
			·745	−21·6	
			728·625	−32·5	
			·636	−25·9	
			·647	−22·5	
			·658	−17·5	
			·669	−18·1	
			·680	−16·7	
			·691	− 7·2	
			·702	0·0	
			·714	− 1·8	
			·725	+ 0·1	
			·736	− 0·7	
			·747	− 9·6	
			·758	− 5·2	
			·769	−20·7	
			·791	−18·1	
			·802	−25·3	
			·818	−25·6	
Lick	Henroteau	1918 May 15	2421729·851	+11·7	Three prisms
			·884	+ 6·2	

RADIAL VELOCITIES OF β CEPHEI—*Continued*

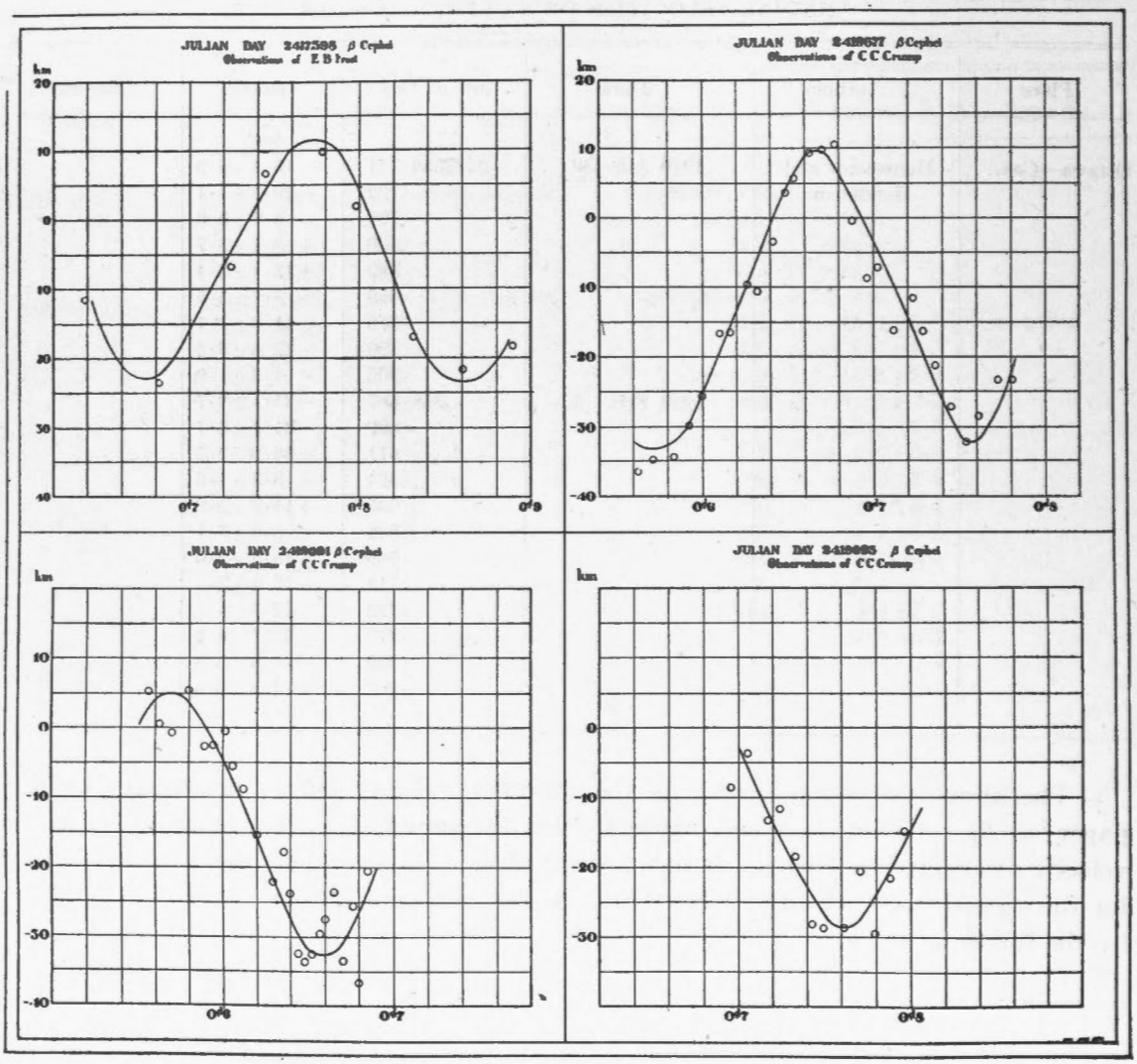
Place	Author	Date	Julian Day	Velocity	Remarks
				km.	
Lick—*Con*.....	Henroteau.....	1918 May 15....	2421729·908	− 3·5	
			·931	−14·6	
			·954	−21·4	
			·985	−19·1	
Ottawa.....	Henroteau and Henderson.	1920 Jan. 19....	2422343·589	+ 1·0	
			·611	−15·9 ±3·0	One prism
			·635	− 8·5 ±4·8	
			·646	−14·2 ±5·6	
			·661	−1· 1 ±3·2	
			·714	−23·8 ±1·9	
			·772	+ 2·0 ±3·4	
			·795	+ 5·0 ±2·4	
			·810	− 1·1 ±3·2	
			·823	+13·9 ±3·6	
			·879	−18·7 ±2·5	
			·892	−16·0	
			·917	−18·4 ±2·7	
		1920 Jan. 21....	345·622	−36·7 ±3·1	
			·633	−34·7 ±2·4	
			·645	− 2·8 ±2·0	
			·705	− 7·1 ±5·1	
			·722	+ 3·0 ±3·1	
			·767	− 8·7 ±3·5	
			·792	−18·4 ±5·5	
			·835	−22·0 ±3·6	
			·852	+ 0·6 ±4·8	
			·866	− 5·4 ±4·5	
		1920 Jan. 25....	349·574	− 8·1 ±7·4	
			·586	−17·8 ±2·5	
			·598	−18·8 ±4·0	
			·636	−30·1 ±2·5	
			·647	−23·7 ±2·2	
			·699	− 6·9 ±3·5	
			·723	+14·0 ±3·1	
		1920 Jan. 28....	352·573	−10·1 ±2·8	
			·651	−31·2 ±2·4	
			·662	−24·7 ±2·2	
			·700	− 8·3 ±3·6	
		1920 Jan. 28....	·711	− 3·8 ±3·1	
			·723	+ 1·8 ±3·6	
			·734	− 3·4 ±3·6	
			·750	+12·9 ±6·5	
			·762	− 1·7 ±4·2	
			·775	+ 0·4 ±5·0	
			·787	+10·6 ±2·0	
			·799	− 1·1 ±3·0	
			·811	− 9·5 ±3·9	
			·823	−16·6 ±2·4	
		1920 Jan. 30....	354·599	−27·2 ±4·6	
			·611	−19·0 ±4·0	
			·623	− 1·6 ±4·0	
			·635	− 9·3 ±4·6	
			·647	− 9·4 ±3·4	
			·658	−20·1 ±3·8	

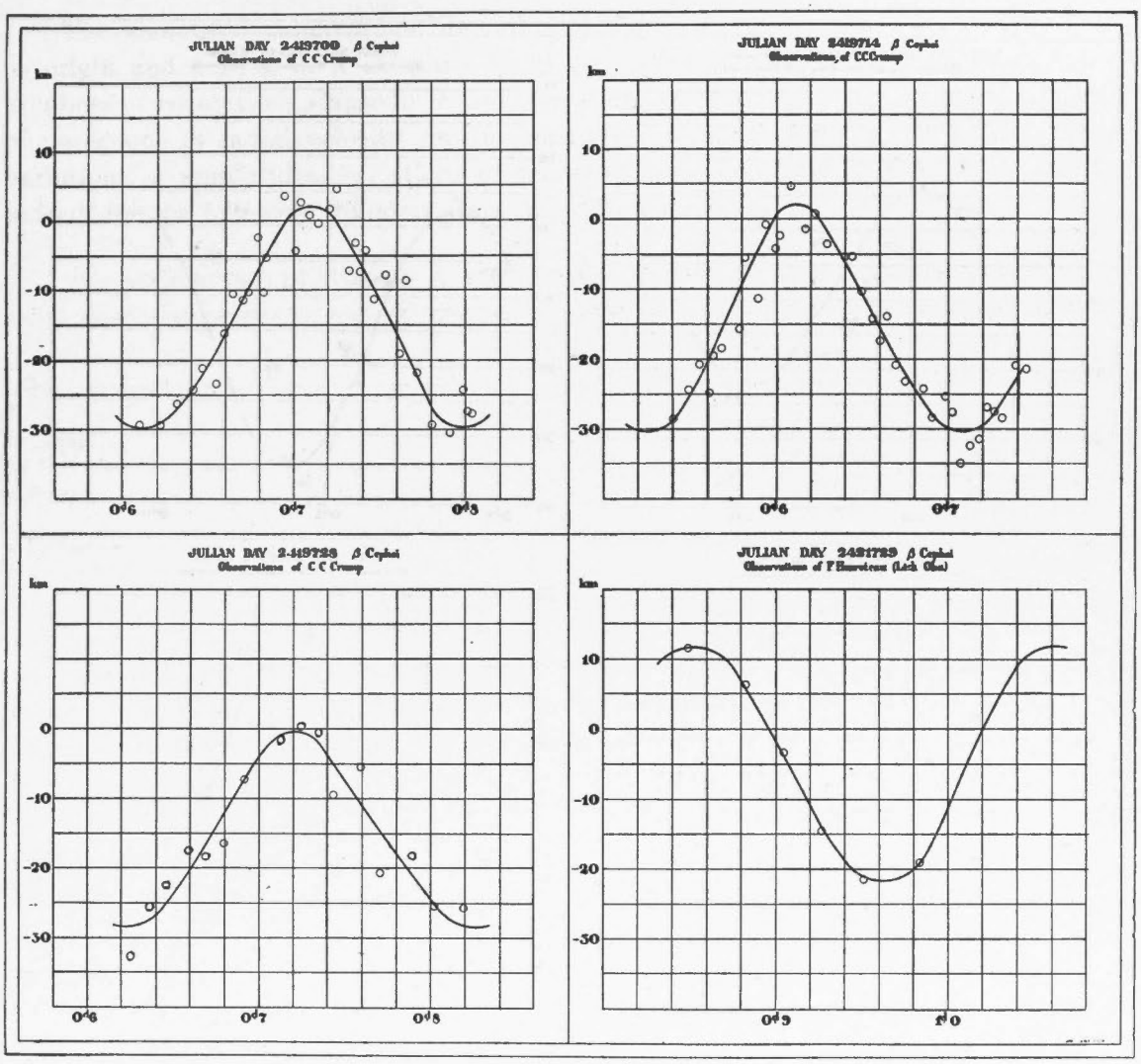
RADIAL VELOCITIES OF β CEPHEI—*Concluded*

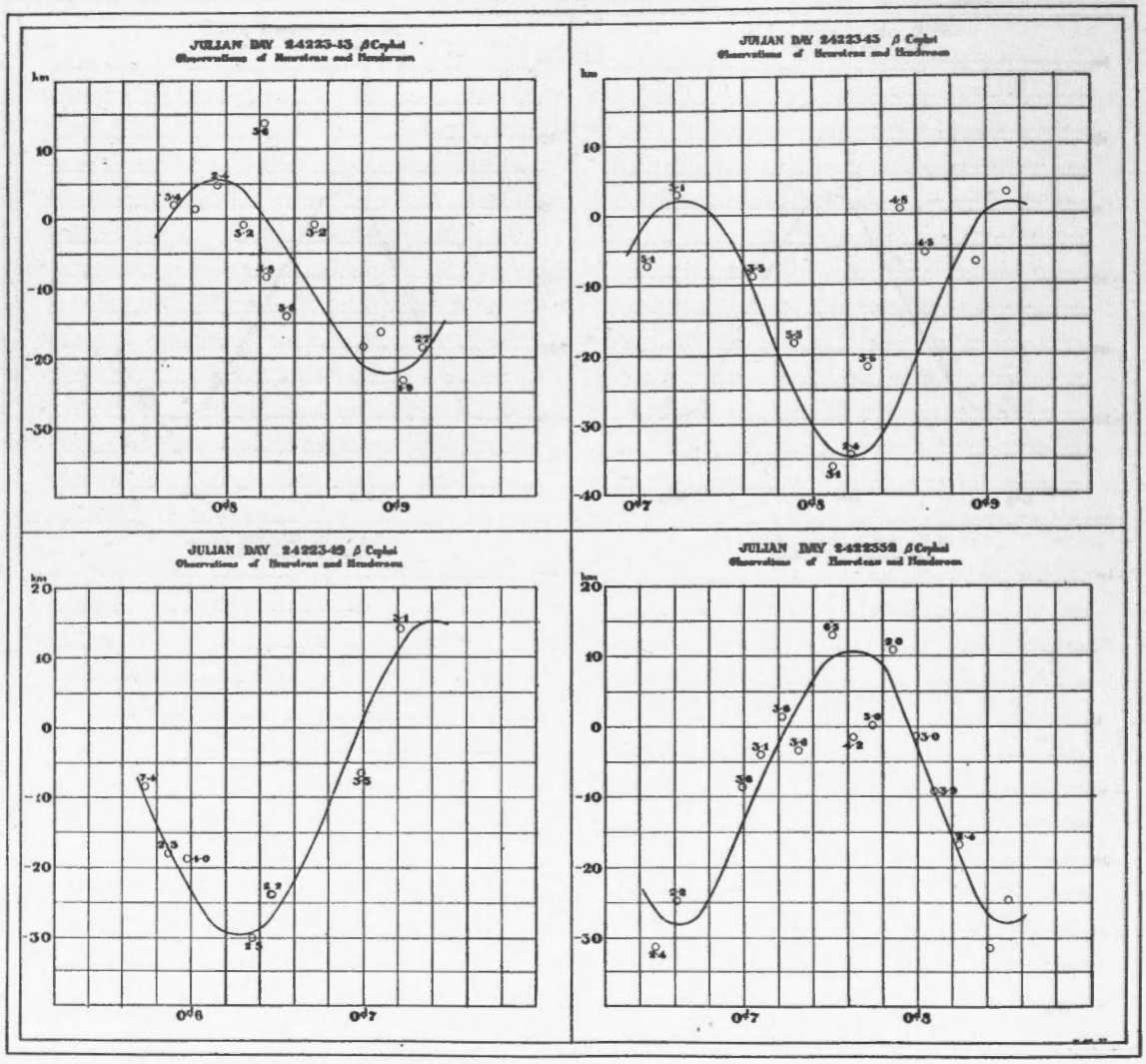
Place	Authors	Date	Julian Day	Velocity	Remarks
				km.	
Ottawa—*Con.*...	Henroteau and Henderson.	1920 Jan. 30....	2422354·711	−15·1 ±5·9	
			·722	−20·3 ±4·1	
			·799	− 4·9 ±3·6	
			·830	+ 3·1 ±3·7	
			·842	+12·1 ±3·4	
			·858	+ 8·7 ±5·5	
			·875	−11·8 ±1·1	
			·890	−12·8 ±3·6	
			·906	− 4·9 ±1·9	
		1920 Feb. 3....	358·587	−25·1 ±2·7	
			·600	−21·4 ±5·7	
			·611	−36·9 ±2·5	
			·624	− 8·3 ±4·6	
			·635	+11·2 ±2·2	
			·648	− 5·0 ±3·1	
			·660	+16·3 ±3·0	
			·711	−17·4 ±2·8	
			·723	−12·5 ±3·8	
			·772	−22·2 ±4·2	
			·792	−14·3 ±5·8	
			·807	−14·4 ±5·6	

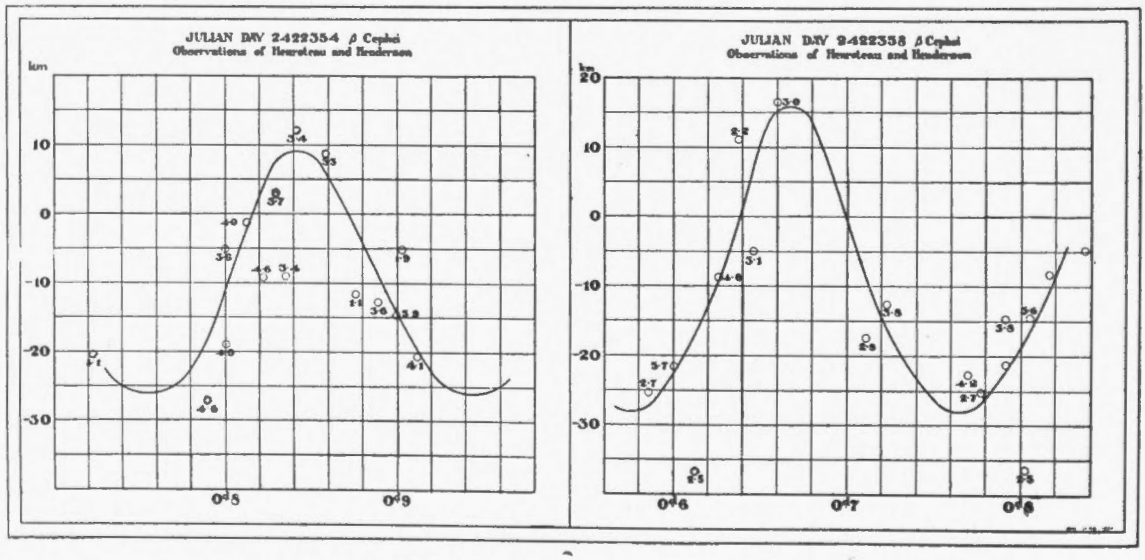
The above velocities furnish us the different velocity curves accompanying this paper (see fig.). They show very markedly that the amplitude of the curves as well as the velocities indicated by their mean axis are variable. The period as found by Dr. Crump for the variation of velocity, $0\cdot^{d}1904795$, verifies our observations very well, as shown by the following table:

Times of Minima		No. of revolutions
Observed J. D.	Computed J. D.	
2419677·758	·758	0
91·658	·663	73
93·762	·758	84
700·800	·806	121
14·709	·711	194
28·626	·616	267
2421729·963	·984	10774
2343·893	·900	13997
45·824	·804	14007
49·634	·614	14027
52·667	·662	14043
54·757	·757	14054
58·769	·757	14075


JULIAN DAY 2417596 β Cephei
Observations of E B Frost
km
20
10
0
10
20
30
40
0d7
0d8
0d9
JULIAN DAY 2419627 β Cephei
Observations of C C Crump
km
20
10
0
10
-20
-30
-40
0d6
0d7
0d8
JULIAN DAY 2419681 β Cephei
Observations of C C Crump
km
10
0
-10
-20
-30
-40
0d6
0d7
JULIAN DAY 2419685 β Cephei
Observations of C C Crump
km
0
-10
-20
-30
0d7
0d8


JULIAN DAY 2419700 β Cephei
Observations of C C Crump
km
10
0
-10
-20
-30
0d6
0d7
0d8
JULIAN DAY 2419714 β Cephei
Observations of C C Crump
km
10
0
-10
-20
-30
0d6
0d7
JULIAN DAY 2419728 β Cephei
Observations of C C Crump
km
0
-10
-20
-30
0d6
0d7
0d8
JULIAN DAY 2421729 β Cephei
Observations of F Hamelrath (Lick Obs.)
km
10
0
-10
-20
-30
0d9
1d0


JULIAN DAY 2422345 β Cephei
Observations of Heurteau and Henderson
JULIAN DAY 2422349 β Cephei
Observations of Heurteau and Henderson
JULIAN DAY 2422352 β Cephei
Observations of Heurteau and Henderson
km
0d8
0d9
0d7


JULIAN DAY 2422354 β Cephei
Observations of Heurteau and Henderson
JULIAN DAY 2422358 β Cephei
Observations of Heurteau and Henderson
km
0d5
0d9
0d6
0d7
0d8

The computed values have been obtained by taking the epoch J.D. 2419677·758 as origin and adding to it as many times the period $0^d \cdot 1904795$ as indicated by the numbers of revolutions elapsed. It is interesting to see how, in these stars, the periods of variations of radial velocity remain accurately constant for many years in spite of variations of amplitudes, variations of centre of mass velocities and so on. We find, indeed, for the following different stars, the different values.

ACCURATE PERIODS OF A FEW STARS OF THE β CANIS MAJORIS TYPE

Star	Period	Author
β Cephei	$0^d \cdot 1904795$	C. C. Crump
12 Lacertæ	$0^d \cdot 1930890$	R. K. Young
σ Scorpii	$0^d \cdot 246829$	M. Selga
	$0^d \cdot 246834$	F. Henroteau
ν Eridani	$0^d \cdot 236672$	F. Henroteau
β Canis Majoris	$0^d \cdot 25714$	F. Henroteau

The last two periods, however, are such that they do not connect all the maxima or all the minima of the different velocity curves, but that either a time of maximum or a time of minimum on each velocity curve can be united by the period. The amplitude of β Cephei, as well as that of 12 Lacertæ, change, but apparently never reaches zero; we might say that the amplitude varies between two positive values. On the other hand, the amplitude of β Canis Majoris becomes zero and even more, becomes negative; it becomes a minimum or a negative maximum.

From the six curves we have obtained in an interval of time of fifteen days only, the second one seems to indicate a mean axis velocity appreciably different from the others; the mean axis velocities being for these six curves respectively −8, −16, −7, −9, −8, and −6 kilometres.

It seems rather difficult to find the law of variation of the centre of mass of the system; the two phenomena, change of amplitude and variation of centre of mass velocity, seem to be interdependent, and it is very significant that only for σ Scorpii, where the amplitude of velocity variation apparently does not change, the curve of variation of the centre of mass velocity has been determined.

1 CASSIOPEIÆ

The spectrum of 1 Cassiopeiæ is not of the best; the lines are rather wide and fairly diffuse, giving separate radial velocities which are sometimes very different from one another. A few line-widths are given in the following table:

Element	λ	Width in angstroms
Hγ	4340·634	2·7 diffuse
He	4388·100	3·5 diffuse
He	4471·676	2·9 diffuse
C	4647·530	5·8 very diffuse

Only two radial velocities have been given before, one by Frost,* −8 km., and the other by W. W. Campbell,† −2 km.

The series of plates obtained here during the same night give the following velocities:

Plate	Date	Velocity	Remarks
8998	1920 Feb. 27·582	−27·1 ± 2·4	6 lines measured
8999	·627	−16·6 ± 6·3	6 lines
9000	·675	−30·1 ± 6·0	7 lines
9001	·728	−15·8 ± 6·3	8 lines
9002	·809	−29·3 ± 7·5	4 lines
9003	·862	−15·8 ± 6·5	5 lines

The type of spectrum being poor, we may consider these velocities as agreeing well with one another; compared with Frost and Campbell's velocities they indicate that the star is probably a spectroscopic binary, but not of very short period.

* Astrophysical Journal, Vol. 32, p. 85.
† Lick Obs. Bull. No. 195.

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