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CANADA
HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

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OTTAWA

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Vol. IX

Astrophysics

No. 5

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First Paper

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FORMER RESEARCH ON THE LIGHT-CURVE

In 1874 Pigott[1] found a light variation of this well-known Cepheid; it is mentioned, however, that Justus Byrgius[2] had noticed some changes in brightness in 1612.

The light-curve has been studied by many observers for more than a century, and a complete bibliography of the observations may be found in "Geschichte und Literatur des Lichtwechsels" by Müller and Hartwig[3]. Since the publication of this valuable compendium many important studies have been made. The following are given particular mention as representative and expert studies;—

(1) Grouiller[4] in his "Monographie de l'étoile variable η Aigle" arrives at the important conclusion that the variation of η Aquilæ cannot be regarded as perfectly regular. Fluctuations occur in the successive maxima and minima of brightness and there is also a slight oscillation of their epochs on each side of a mean value. It would, however, be very difficult to study these variations by means of visual observations.

(2) Wylie[5] in 1920 determined a light-curve with a photo-electric photometer, introducing a new era in the investigation of Cepheids; the accuracy of the curve obtained will make it possible after further investigation to find out definitely whether there are alterations in the shape of the curve and if necessary the nature of these alterations. Wylie's light-curve, a marvel of modern scientific method, may be found on page 225 of the Astrophysical Journal mentioned. The "secondary maximum" is confirmed as a pronounced halt in the decrease of light, from phase $1^d.8$ to $2^d.4$. Another fluctuation is indicated with maximum about phase $4^d.3$. Comparison with previous observations suggests a shortening of the interval from minimum to maximum since 1900 and a gradually increasing period.

(3) Nÿland[6] from a large number of observations does not think that the aspect of the light-curve has changed appreciably in an interval of twenty years.

(4) Very different are the results of Hopmann[7], who from his colorimetric observations considers the secondary hump to be of variable amplitude. He estimates that this amplitude has approximately an 11-year period, being a maximum in the years 1900, 1910, 1920 and a minimum in 1896, 1908, 1918, 1928.

(5) The conclusions of Friedrich Becker[8], based on a large number of observations by Plassmann, confirm Hopmann's deductions. Seven mean curves were determined, each from fourteen normal places and for different epochs as follows:—

[1] Phil. Trans. Vol. 75, 1785, p. 129.
[2] Berl. Jahrbuch 1817, p. 117.
[3] Vol. 2, p. 229.
[4] B.A., 2e série Tome 1, p. 331.
[5] Ap. J, Vol. 56, p. 217.
[6] Recherches de l'observatoire d'Utrecht Vol. 8 lère partie, p. 40.
[7] A.N., Vol 222, p. 1.
[8] A.N., Vol. 225, p. 1. *See also* Die Himmelswelt, Vol. 35, 1925, p. 160.

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Curve	Year	Number of observations	Probable error of one observation
			m
I	1895–1899	196	±0·085
II	1899–1903	194	0·094
III	1903–1907	200	0·084
IV	1908–1912	233	0·092
V	1913–1917	237	0·092
VI	1918–1921	250	0·109
VII	1921–1924	224	0·094

The fourteen normal places for each curve are as follows (phase and magnitude). The results are exhibited graphically in fig. 1[1].

I		II		III		IV		V		VI		VII	
d	m	d	m	d	m	d	m	d	m	d	m	d	m
0·318	3·68	0·164	3·65	0·314	3·74	0·305	3·78	0·303	3·80	0·263	3·78	0·317	3·71
0·734	3·73	0·663	3·81	0·792	3·83	0·876	3·93	0·707	3·84	0·722	3·84	0·751	3·91
1·223	3·85	1·311	3·87	1·444	3·90	1·296	4·05	1·362	4·01	1·244	3·94	1·160	3·99
1·747	3·97	2·007	3·97	1·841	4·03	1·839	4·05	1·829	4·08	1·771	4·01	1·727	4·02
2·250	3·95	2·486	3·95	2·325	4·03	2·329	4·06	2·347	4·06	2·180	3·96	2·201	4·07
2·918	4·17	2·904	4·12	2·753	4·08	2·895	4·12	2·830	4·13	2·576	4·08	2·823	4·12
3·353	4·24	3·365	4·29	3·206	4·17	3·404	4·22	3·453	4·19	3·047	4·25	3·202	4·25
3·757	4·38	3·866	4·37	3·703	4·23	3·954	4·29	3·853	4·33	3·537	4·24	3·641	4·29
4·282	4·49	4·205	4·45	4·304	4·30	4·356	4·44	4·442	4·43	3·982	4·34	4·228	4·43
4·722	4·51	4·638	4·45	4·918	4·43	4·822	4·47	5·045	4·46	4·439	4·33	4·713	4·44
5·172	4·59	5·038	4·53	5·501	4·40	5·391	4·48	5·566	4·44	5·025	4·50	5·247	4·50
5·694	4·48	5·553	4·54	5·905	4·30	5·826	4·29	6·193	4·23	5·679	4·43	5·838	4·36
6·146	4·21	6·158	4·25	6·390	4·10	6·321	4·12	6·617	3·94	6·330	4·10	6·403	4·09
6·875	3·80	6·846	3·74	6·840	3·79	6·831	3·91	7·018	3·76	6·887	3·84	6·965	3·84

[1]See also A.N. Vol. 225, p. 1.

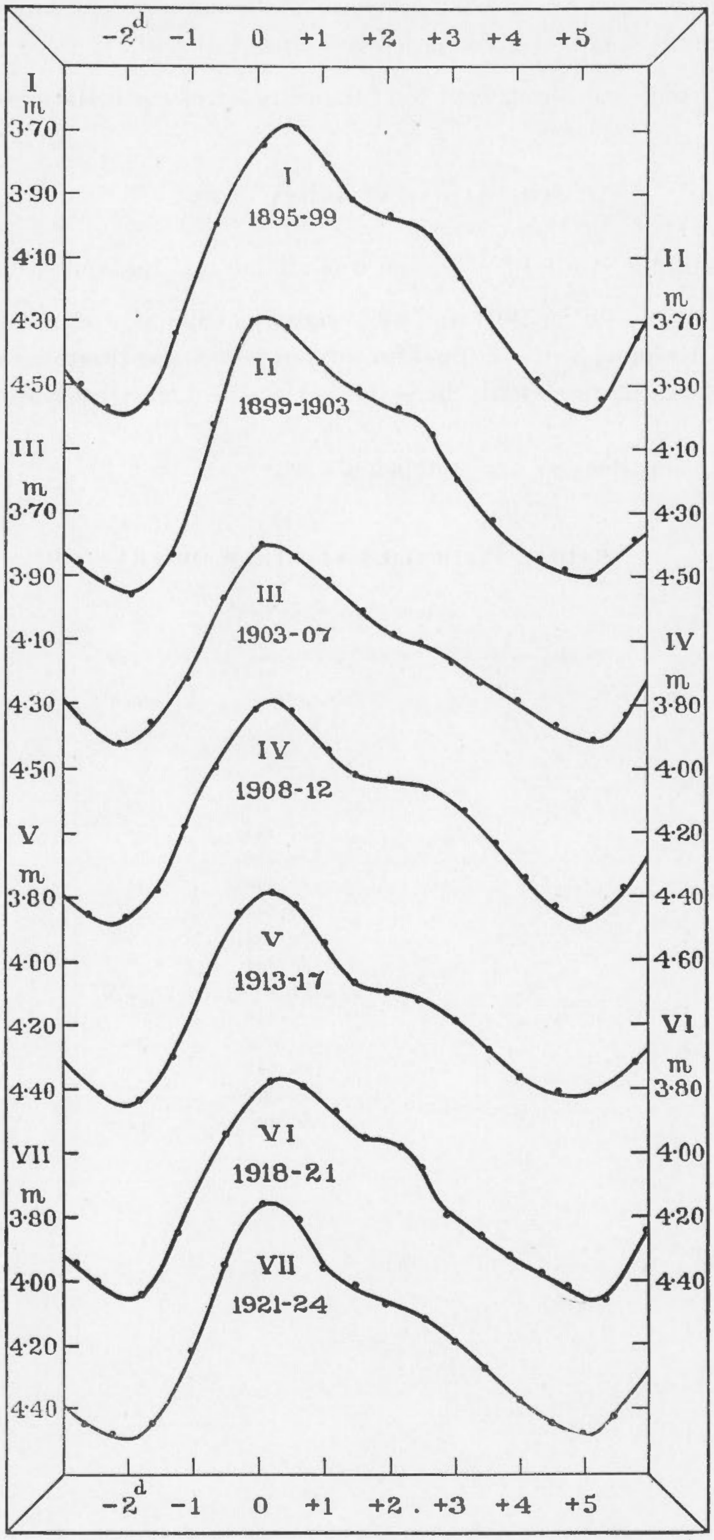

Fig. 1—Light curves of η Aquilæ obtained by Becker from Plassmann's observations

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The changes in shape are decided; several of the curves show large humps, while in other cases the hump is not so marked or even almost absent.

These results indicate a rich field for further research with the photo-electric photometer.

THE RADIAL VELOCITY CURVE

The spectrographic study of η Aquilæ was abandoned for some years.

Studied by Bélopolsky[1] in 1897 and by Wright[2] in 1898, it was not until twenty years later that it was resumed with the making of forty-two spectrograms at the University of Michigan. It was more recently investigated at the Lick Observatory by Jacobsen[3].

The radial velocities so far published are:—

RADIAL VELOCITIES AT OTHER OBSERVATORIES

(Bélopolsky's velocities)

Date	Julian Day G.M.T.	Velocity km.	Remarks
1897 July 10	2414116·344	−28·7	
11	117·344	−28·9	
12	118·385	−20·0	
13	119·344	−11·7	
17	123·344	−25·5	
21	127·344	− 9·6	
22	128·344	+ 0·2	
25	131·302	−32·0	
25	·344	−29·0	
26	132·302	−24·4	
30	136·344	+ 4·4	
Aug. 2	139·302	−27·1	
13	150·302	+ 1·0	

[1] Ap. J, Vol. 6, 1897, p. 393.
[2] Ap. J., Vol. 9, 1899, p. 59.
[3] L.O.B., Vol. 12, 1926, p. 147.

RADIAL VELOCITIES AT OTHER OBSERVATORIES—Continued

(Wright's Velocities)

Date	Julian Day G.M.T.	Velocity km.	Remarks
1898 June 21	2414462·882	−25·3	
27	468·901	−30·6	
28	469·887	−25·2	
July 4	475·930	−30·4	
5	476·858	−24·5	
12	483·903	−27·7	
19	490·867	−28·6	
26	497·821	−28·8	
Aug. 2	504·729	−29·8	
6	508·798	− 0·3	
7	509·727	+ 9·0	
7	·791	+11·4	Campbell +11·4
8	510·724	−14·1	
15	517·728	− 9·2	
19	521·753	−14·6	
21	523·758	+ 2·7	
25	527·685	−23·6	
25	·742	−20·6	
26	529·687	−16·6	
28	530·697	+ 1·7	Campbell +1·5
29	531·672	+ 8·0	
30	532·676	−28·8	
Sept. 9	542·726	−19·5	
17	550·643	−12·4	
18	551·671	− 6·7	
Oct. 9	572·640	−14·3	Campbell −13·5
10	573·637	+ 0·8	
17	580·733	+ 0·1	

(Küstner's velocities)

Date	Julian Day G.M.T.	Velocity km.	Remarks
1909 Aug. 12	2418531·44	−26·8	A. N. n° 4750
1912 Oct. 5	2419651·29	−18·0	

(Lunt's velocities)

Date	Julian Day G.M.T.	Velocity km.	Remarks
1910 Aug. 22	2418906	−13·9	Ap. J. Vol. 50 p. 171
1911 Sept. 6	2419286	−20·7	
1912 Aug. 23	2419638	−17·5	

RADIAL VELOCITIES AT OTHER OBSERVATORIES—Concluded

(*Jacobsen's velocities*)

Date	Julian Day G.M.T.	Velocity km.	Remarks
1923 June 30	2423601·889	− 0·17	
July 1	602·975	+ 5·63	
2	603·963	−29·57	
4	605·943	−22·83	
6	607·948	−14·25	
9	610·962	−24·85	
10	611·937	−30·82	
11	612·933	−24·19	
12	613·947	−18·01	
14	615·958	− 3·67	
21	622·925	− 6·51	
24	625·913	−31·47	
Aug. 2	634·917	−23·39	
3	635·897	−15·87	
19	651·918	− 2·59	
20	652·824	+ 9·10	
30	662·853	−26·32	
Sept. 6	669·810	−28·80	
16	679·747	−13·90	
23	686·770	−13·60	
28	691·748	−25·10	
30	693·743	−14·66	
Oct. 10	703·706	− 1·86	
15	708·641	−12·94	
16	709·628	+ 1·64	
18	711·626	−29·96	
28	721·609	−16·58	
Nov. 2	726·661	−30·61	
1925 Nov. 27	2424481·629	−29·85	Astronomical date changed by 12 hours, but Julian Day unchanged.
Dec. 6	490·616	−18·33	
9	493·621	+ 8·76	
16	500·618	−15·80	

Following are the radial velocities of η Aquilæ obtained at Ottawa. The plates were measured against a standard spectrogram of Polaris, the same that was used for other Cepheids.

OTTAWA RADIAL VELOCITIES OF η AQUILÆ

Date	Julian Day G.M.T.	Velocity km.	Remarks
1924 Aug. 7	2424005·645	−25·2	
8	006·601	−29·4	
10	008·700	−13·0	
11	009·585	−15·2	
12	010·699	− 5·1	
14	012·581	−16·5	

OTTAWA RADIAL VELOCITIES OF η AQUILÆ—Concluded

Date	Julian Day G.M.T.	Velocity km.	Remarks
1924 Aug. 14	2424012·668	−19·6	
15	013·692	−32·0	
18	016·569	−13·1	
24	022·677	−20·4	
25	023·645	− 9·9	
26	024·585	− 8·2	
27	025·593	+ 0·2	
29	027·586	−31·5	
Sept. 2	031·601	− 8·9	
3	032·588	+ 4·3	
4	033·569	+14·3	
5	034·581	−32·3	
11	040·565	+ 6·2	
14	043·551	−26·8	
17	046·552	− 2·5	
18	047·566	+ 8·2	
19	048·551	−20·5	
26	055·550	−12·9	
1925 June 24	325·717	− 8·7	Astronomical date changed by 12 hours, but Julian Day unchanged.
27	328·707	−23·3	
29	330·742	−14·8	
July 1	332·697	−14·7	
3	334·718	+ 6·5	
6	337·702	−23·0	
8	339·701	−11·8	
9	340·707	− 1·4	
11	342·694	−15·7	
13	344·743	−23·0	
14	345·726	−18·9	
20	351·693	−25·8	
27	358·708	−28·4	
Aug. 4	366·678	−18·2	
5	367·616	−16·7	
8	370·641	+13·2	
12	374·640	−12·5	
17	379·628	−30·2	
21	383·605	− 4·6	
22	384·610	+ 9·3	
25	387·591	−25·8	
26	388·647	−18·9	
27	389·558	−14·2	
27	·635	−15·4	
28	390·589	− 6·0	
31	393·637	−30·7	
Sept. 1	394·616	−22·6	
2	395·572	−21·8	
9	402·551	−20·0	
15	408·542	−32·3	
15	·613	−29·0	
22	415·545	−35·1	
Oct. 5	428·581	+ 0·3	

The Ottawa velocities, together with the elements J.D. 2414827·150 ± 7^d.176678 E, have been utilized for the curves shown in figs. 2 and 3.

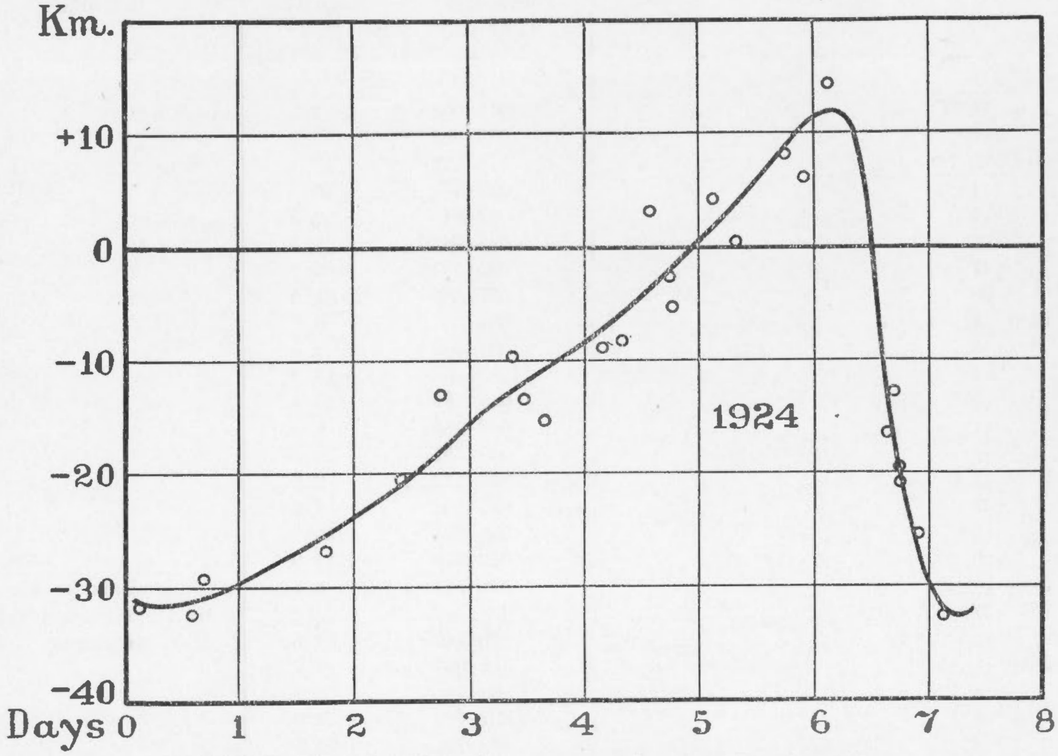

Fig. 2—Radial Velocity curve of η Aquilæ in 1924

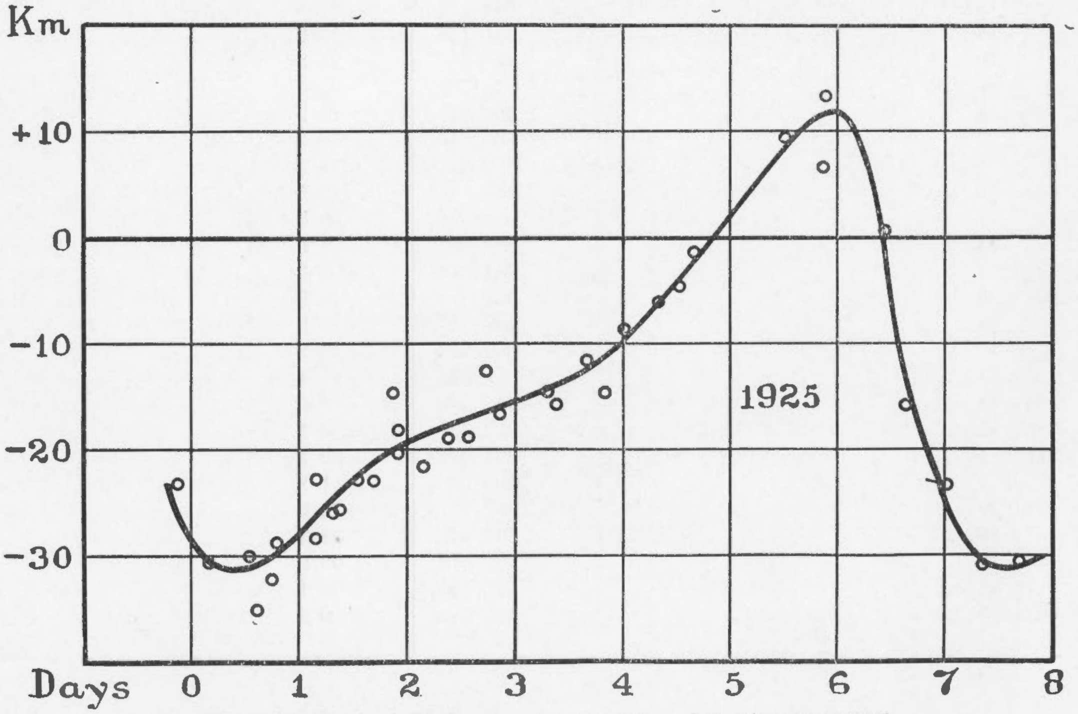

Fig. 3—Radial Velocity curve of η Aquilæ in 1925

The curve in fig. 3 is very similar to that found by Jacobsen in 1923 and shows a marked hump on the ascending branch probably corresponding to the hump on the descending branch of the light-curve. There are not, however, enough observations to determine this hump with any great degree of certainty on the curve of 1924.

VELOCITIES FROM INDIVIDUAL LINES

Research on the radial velocities given by individual lines in the spectra of Cepheids was mentioned in the writer's paper on ζ Geminorum[1]; this work was initiated by R. H. Curtiss, W. Carl Rufus and J. A. Aldrich. In the particular study of η Aquilæ by Dr. W. Carl Rufus[2] it was found that lines of different levels did not give the same velocity curve. Dr. Rufus obtains what he calls velocity-difference curves, such as velocity of high level minus velocity of intermediate level, or high-minus-low curve, or hydrogen-minus-intermediate curve. The following extracts from Rufus' article will give a clear idea of his results:—

"Velocity-difference curves correlated with the light variation and other periodic changes characterize the method here applied. The radial velocities of concentric layers of the star's atmosphere are determined separately by isolating certain elements, and by grouping lines of the spectrum originating at assumed levels based upon the determination of their heights in the sun by St. John[3] and by Mitchell[4]. The approach of two layers indicates compression of the intervening gases and recession indicates expansion. Resulting changes in temperature, density, radiation, and absorption, may be correlated with the light variation and changes of spectrum to explain many of the anomalous characteristics of Cepheid variation. Inasmuch as spectroscopic work is limited to surface radiations characterized by atmospheric effects, a new method of analysis to determine changes of atmospheric conditions should yield results of fundamental significance."

In η Aquilae "the hydrogen-minus-intermediate curve has an amplitude greater than 20 km., which exceeds one-half the amplitude of the velocity curve itself. Special attention is called to the similarity of this velocity-difference curve to Wylie's photometric light-curve, and to a spectral variation curve based upon Shapley's data[5]. The intermediate-minus-low curve resembles the reverse of the light-curve with synchronous secondary features. The 'humps' of the velocity-difference curves are synchronous with the 'stillstand' of the light-curve, which is not true in the case of the velocity curves. The 'stillstand' of the light variation seems to be due to a stage of comparative rest in the atmosphere of the star."

In a further study of ζ Geminorum Rufus[6] finds phenomena analogous to what he found in η Aquilæ. Twenty-six selected lines were grouped at three levels, six high, six intermediate and fourteen low. High-minus-low and high-minus-intermediate curves were formed by plotting the velocity differences with respect to phases. The amplitude of these curves is greater than one-third that of the velocity curve itself.

[1] Pub. Dom. Obs., Vol. 9, p. 111.
[2] Proc. Nat. Acad. Sc., Vol. 10, 1924, p. 264.
[3] Ap. J., Vol. 37, 1913, p. 322 and Vol. 38, 1913, p. 341.
[4] Ap. J., Vol. 38, 1913, p. 407.
[5] Ap. J. Vol. 44, 1916, p. 287.
[6] Pop. Ast., Vol. 34, 1926, p. 242.

These results do not agree with those obtained at Ottawa, as can be gathered from the curves given on page 114 of the present volume; all these curves are practically identical and do not suggest the existence of velocity-difference curves.

δ Cephei and η Aquilæ were investigated by Jacobsen[1] at the Lick Observatory by the use of a specially built 3-prism spectrograph giving the violet region. The velocity differences for δ Cephei show no relation to phase. In η Aquilæ there seems to be a high-minus-low effect of the nature found by Rufus but of considerably smaller amplitude. The following table gives Jacobsen's results:—

δCephei			ηAquilæ		
Phase	High minus low	Intermediate minus low	Phase	High minus low	Intermediate minus low
	km.	km.		km.	km.
0d·21	+3·0	+6·1	0d·24	−2·0	+5·9
0·68	+0·4	+5·5	2·09	−0·7	+4·6
2·53	+5·5	+8·8	2·35	−1·6	+3·6
3·52	+1·1	+1·8	6·09	+3·6	+5·4
3·56	+3·6	+8·2	6·23	+6·2	+5·1
4·78	+0·8	+5·1	7·15	−4·0	+2·7

Jacobsen considers his results, however, as only preliminary.

The results obtained here for individual lines of η Aquilæ agree with those of Jacobsen but not so well with those of Rufus. It appears that the dispersion of the Detroit spectrograms is not so great as those of Lick and Ottawa, and that the slit-width used was somewhat greater. The possibility is suggested that the results of Rufus may be due to blends of ionized and neutral lines; it is known that the relative intensities and widths of many such pairs vary considerably during the variation-cycle of the star; such variations in the case of a close unresolved pair would produce just such apparent changes in radial velocity as observed by Rufus.

Measures of individual lines were made on a direct measuring microscope by Mr. J. F. Frédette of this Observatory and on the spectro-comparator by the writer. The direct measures have been combined into normal places which are in the following tables:—

[1] L.O.B., Vol. 12, p. 151.

Sr^{+}4215·7
(1924 and 1925)
6000 km. level in Sun

Phase	Velocity	Weight
	km.	
7^d·15	−28·8	11
0·68	−21·5	10
1·21	−13·9	6
1·75	−11·0	8
2·29	−15·2	5
2·69	− 5·0	8
3·51	− 5·3	3
4·24	− 2·7	4
4·80	+ 8·7	7
5·93	+17·2	7
6·60	+ 1·6	8
6·77	−13·7	7

Fe 4260·6
(1925)
600 km. level in Sun

Phase	Velocity	Weight
	km.	
7^d·14	−22·2	3
0·67	−29·5	7
1·25	−33·1	7
1·75	−24·9	14
2·23	−16·0	5
2·71	−17·8	10
3·66	−14·7	6
4·11	−10·4	4
4·60	− 8·9	6
5·82	+ 7·6	7
6·59	− 8·5	6

Fe 4325·9
(1925)
900 km. level in Sun

Phase	Velocity	Weight
	km.	
7^d·11	−23·3	1
0·72	−25·3	8
1·25	−17·8	5
1·78	−21·1	11
2·21	−19·6	3
2·71	− 9·9	9
3·56	−12·0	4
4·11	− 2·0	4
4·68	− 0·7	1
5·81	+10·3	6
6·55	− 6·3	4

$H\gamma$ 4340·6
(1925)

Phase	Velocity	Weight
	km.	
7^d·20	−28·4	2
0·70	−33·0	3
1·19	−28·4	6
1·79	−19·9	8
2·19	−24·8	4
2·65	−13·7	7
3·63	− 6·4	3
4·11	− 4·8	4
4·60	− 6·0	
5·73	− 1·8	5
6·55	+ 1·4	2

Mg^{+}4481·4
(1925)

Phase	Velocity	Weight
	km.	
7^d·20	−39·9	2
0·67	−21·6	6
1·25	−16·2	6
1·76	−20·0	8
2·26	−18·2	2
2·70	−18·6	4
3·62	−20·5	5
4·04	−18·1	2
4·52	− 2·8	1
5·75	+ 9·0	3
6·49	− 6·8	4

Ti 4549·7
(1924 and 1925)
1300 km. level in Sun

Phase	Velocity	Weight
	km.	
7^d·14	−23·9	18
0·65	−27·2	16
1·27	−17·8	6
1·78	−19·6	17
2·31	−17·2	6
2·76	−13·4	14
3·52	− 9·9	14
4·23	− 6·6	9
4·78	− 0·8	12
5·80	+11·1	13
6·60	− 4·5	12

In addition, for the mean of the three lines Ti 4395·2, Fe 4415·3 and Ti 4549·7 whose respective levels in the sun are 2500 km., 500 km., and 1300 km., we have the following values:—

Phase	Velocity	Weight
	km.	
7d·02	−21·4	35
0·67	−26·2	26
1·23	−18·2	14
1·77	−17·4	40
2·25	−17·0	13
2·73	−10·7	34
3·54	− 8·2	24
4·16	− 7·3	23
4·70	− 1·5	22
5·77	+13·4	26
6·56	− 1·0	20

The first six series of measures give the velocity curves in fig. 4 and the last series the curve in fig. 5.

The ionized lines Sr^+4215·7 and Mg^+4481·4 give velocity curves having an amplitude of nearly 50 km. with pronounced secondary humps. The low-level lines also give a pronounced hump, while this hump is not so marked for intermediate levels agreeing with Rufus' results.

The neutral lines give amplitudes of nearly 40 km.

From comparison with spectro-comparator measures we place little confidence in the real existence of a flattened maximum in the Hγ curve.

The five separate lines Sr^+4215·7; Hγ; Fe 4415·3; Ti^+4534·1 and Ti 4534·9 measured on the spectro-comparator give the following velocities corresponding to phases.

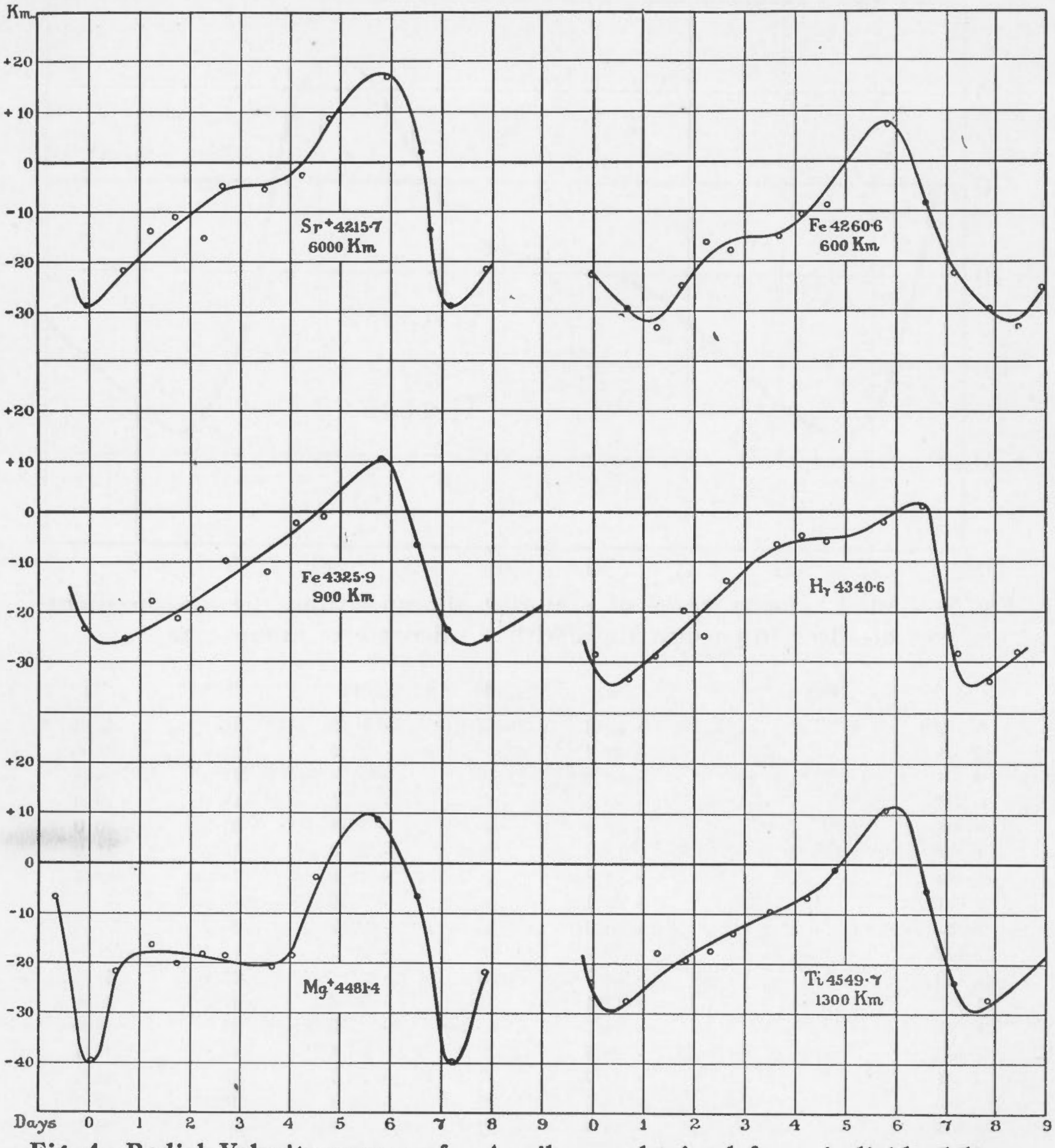

Fig. 4—Radial Velocity curves of η Aquilæ as obtained from individual lines measured with a micrometer microscope

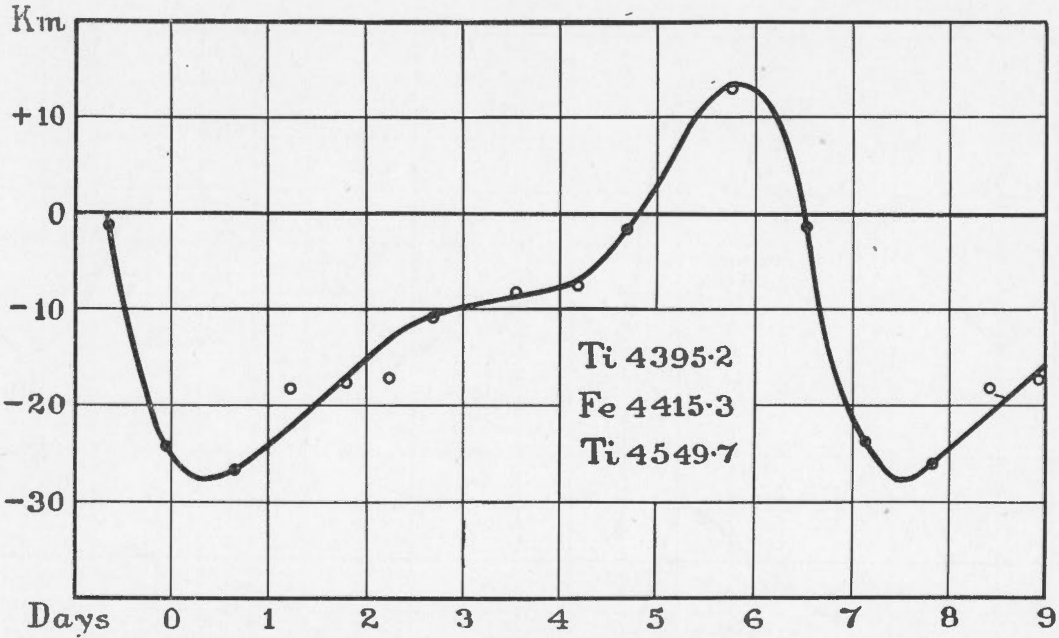

Fig. 5—Radial Velocity curve of η Aquilæ obtained from the measurement of three important lines with a micrometer microscope

Phase	Sr^+	$H\gamma$	Fe	Ti^+	Ti
0d·195	−40·3	−45·8	−40·3	−33·9	−42·9
0·538	−24·4	−35·7	−27·5	−23·0	−34·6
0·570	−42·8	−39·1	−31·4	−31·4	−26·3
0·747	−36·2	−37·6	−33·5	−48·0	−49·3
0·818	−32·2	−43·3	−28·8	−33·9	−30·0
1·148	−12·3	−28·0	−28·3	−32·5	−31·2
1·174	−33·8	−55·5	−29·0	−38·3	−46·1
1·310	−22·1	−36·7	−26·9	–	–
1·325	−36·2	−25·9	−26·3	−20·1	−27·9
1·535	−20·9	−43·5	−27·2	−16·3	−27·9
1·671	−22·7	−26·8	−21·6	−22·0	−31·1
1·887	−32·1	−31·7	−29·4	−37·2	−39·8
1·932	−28·0	−45·5	−37·3	−29·1	−33·0
1·941	−28·7	−23·1	−23·9	−37·7	−35·1
2·130	−32·7	−27·5	−20·7	−16·4	−31·9
2·381	−18·0	−32·8	−19·4	−29·4	−37·1
2·518	−26·4	−22·7	−19·3	−10·3	−25·7
2·727	−24·6	−22·7	−17·3	−14·7	−18·6
2·879	−23·1	−24·7	−14·9	−12·4	−22·8
3·290	−18·2	−37·5	−14·8	−16·7	−14·1
3·369	−17·4	−38·8	−19·8	−24·6	−31·1
3·670	−26·7	−19·9	−22·5	−16·5	−19·1
3·842	−19·5	−21·2	−18·2	−27·6	−27·6
4·038	− 9·6	−23·3	− 7·7	+ 1·2	−11·7
4·323	−18·7	−40·2	−11·7	−19·7	−26·2
4·515	−16·2	−16·4	−16·4	− 5·6	−18·5
4·676	− 7·1	−11·7	− 7·8	− 5·7	−12·1
5·520	+ 8·0	−11·1	+ 7·1	+ 1·8	+ 1·8
5·863	+ 5·1	+ 1·4	+ 3·5	+ 2·5	+ 5·1
5·904	+ 4·0	+10·7	+ 7·4	+11·9	− 1·0
6·434	− 7·1	−11·8	− 4·7	− 2·2	−13·8
6·683	−10·7	− 8·8	−14·2	−16·5	−21·7
7·028	−37·2	−44·2	−26·0	−18·1	−32·3

The radial velocity curves obtained from these values for Sr^{+}, $H\gamma$ and Fe are given in fig. 6.

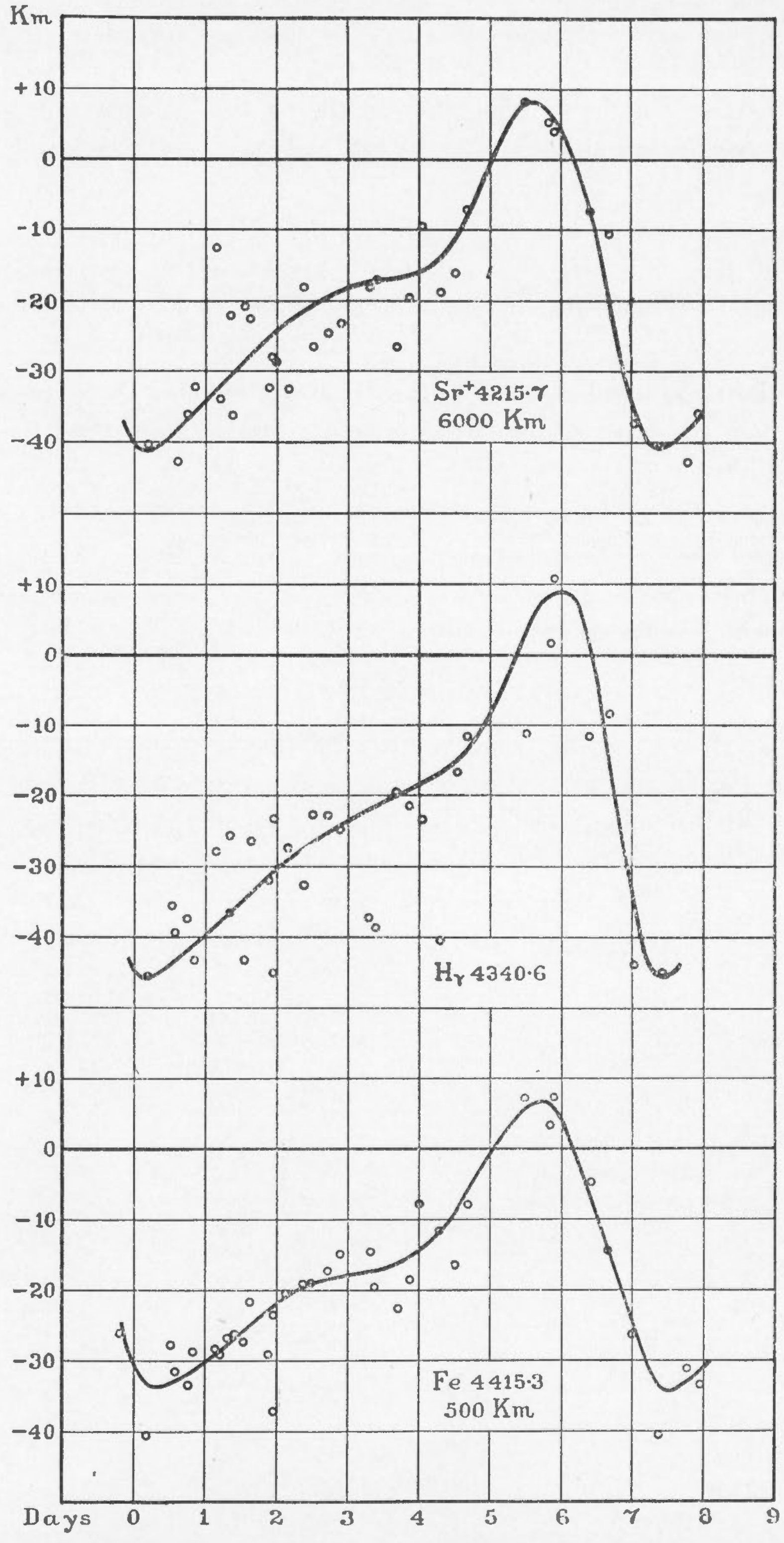

Fig. 6—Radial Velocity curves of η Aquilæ as obtained from individual lines measured on the spectro-comparator

The Fe line is excellent, Sr^+ is broader but good, while $H\gamma$ is difficult to measure. The lines Ti^+ and Ti are poor and close together, a circumstance which might influence the accuracy of their measurement; the curves which they furnish indicate amplitudes of nearly 50 km or more for Ti^+ and of nearly 40 km. for Ti. These two titanium lines are used by the writer for the determination of the amount of ionization in Cepheids.

The Sr^+ curve has an amplitude of 50 km., as has the $H\gamma$ curve. The Fe curve has an amplitude of 40 km.

If it is remarked that all so called high-level lines are likely to be ionized lines, and low-level neutral lines, it is seen that our results agree with those of Jacobsen who also finds that the high-level lines give an amplitude about ten kilometers larger than the low-level lines.

It must be borne in mind that the ionized lines in Cepheids are prominent but much less numerous than the neutral lines, which explains that the mean radial-velocity curve has the same amplitude as the neutral-line curves.

The net result of the present radial velocity investigation is as follows:—

1. *The neutral lines give a radial-velocity curve having an average amplitude of 40 km.*
2. *The ionized lines give a radial-velocity curve having an average amplitude of 50 km.*
3. *The secondary hump is present in all.*

VARIATION OF SPECTRAL CLASS

The relative intensity of the titanium lines Ti^+4534·139 and Ti 4534·953 has been estimated on the spectrograms of η Aquilæ. While both lines actually vary, the intensity of the arc line was throughout assumed as 10, and that of the enhanced line estimated in terms of it. The following table gives these relative intensities.

Date	Phase	Intensity	Weight
1924 Aug. 7	6d·90	12	3
10	2·78	9	2
11	3·66	12	3
12	4·78	8	3
14	6·66	13	5
14	6·75	15	5
15	0·60	12	3
18	3·48	9	2
24	2·41	14	1
25	3·37	10	3
26	4·31	7	3
27	5·32	10	3
Sept. 2	4·15	8	3
3	5·14	7	4
4	6·12	10	3
5	7·13	17	3
11	5·94	15	4
17	4·75	8	3
18	5·77	11	1
19	6·75	14	4
26	6·70	18	3

Date			Phase	Intensity	Weight
1925	June	24	4·04	10	4
		27	7·03	18	4
		29	1·89	10	5
	July	1	3·84	7	3
		3	5·86	11	5
		6	1·67	14	4
		8	3·67	9	1
		9	4·68	7	4
		11	6·68	18	5
		13	1·54	10	5
		14	2·52	11	5
		20	1·31	11	2
		27	1·15	16	4
	Aug.	4	1·94	9	3
		5	2·88	13	3
		12	2·73	8	4
		17	0·54	13	3
		21	4·52	8	3
		22	5·52	8	4
		25	1·33	12	4
		27	3·29	10	3
		27	3·37	7	4
		28	4·32	10	4
		31	0·20	15	1
	Sept.	1	1·17	13	1
		2	2·13	6	3
		9	1·93	10	5
		15	0·75	16	5
		15	0·82	15	4
		22	0·57	16	4
	Oct.	5	6·43	14	4

If the values of weight 1 are omitted these measures give the curve of ionization change in fig. 7 where the crosses indicate the 1924 observations and the circles those of 1925. The weights of the observations are entered in the figure.

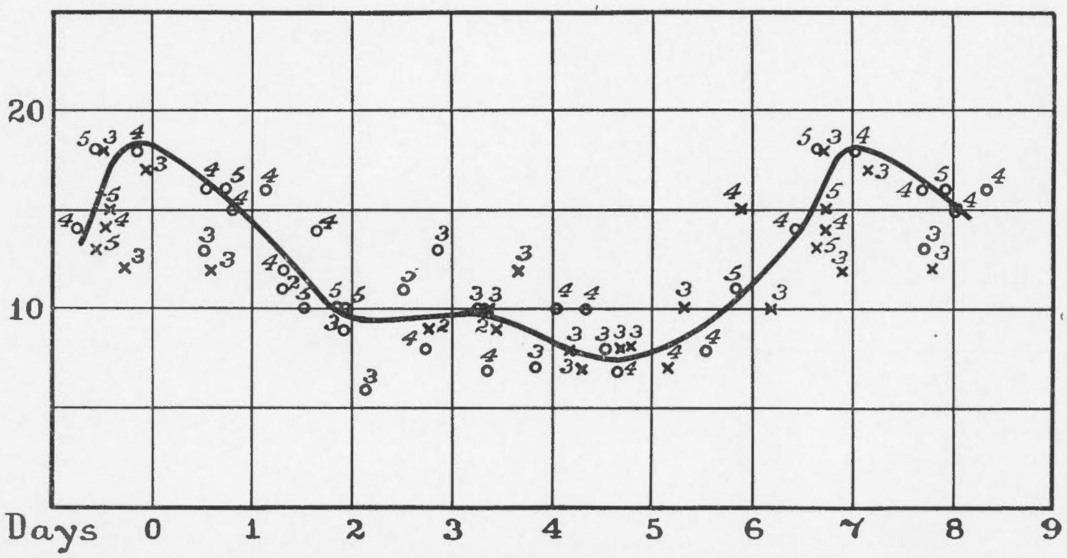

Fig. 7—Ionization curve for η Aquilæ or relative intensity of the two lines Ti⁺ 4534·139 and Ti 4534·953

The ionization curve resembles the light-curve more than the radial-velocity curve. From phase zero on the ionization drops quickly and is followed by a "stillstand" corresponding to the hump of the light-curve; it reaches a minimum at about phase five days just as the light does, and this about one day before the maximum radial velocity.

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DOMINION OBSERVATORY, OTTAWA.

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