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**The Spectroscopic System
Sigma Scorpii**

Second Paper

BY

F. HENROTEAU, Ph.D.

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THE SPECTROSCOPIC SYSTEM SIGMA SCORPII

SECOND PAPER

BY F. HENROTEAU, PH.D.

The present paper gives the results of the observations of σ Scorpii in 1922. In a former paper* an extensive study of this star has already been made; it was found that the variation of the radial velocity followed two periods, a very short one of $0^d.246834$ and a much longer one of about 34 days. It was also found that the variation of long period had a variable amplitude. In order, however, to arrive at an understanding of the system, observations will have to be secured for a number of years; it is therefore the intention to follow the star for several years and to publish the results obtained each year. The assistance of Mr. J. F. Frédette in the present research is acknowledged.

The radial velocities obtained for σ Scorpii in 1922 are as follows:—

RADIAL VELOCITIES OF σ SCORPII

Date	Julian Day	Velocity km.	Remarks
1922 April 2.....	2423147.759	-27.3	
	.786	-25.7	
	.808	-35.8	
	.831	-16.3	
	.853	- 8.5	
	.876	- 3.0	
April 4.....	149.789	-30.9	
	.812	-33.1	
	.837	- 6.5	
	.865	+ 3.6	
	.890	+ 2.7	
April 5.....	150.752	-38.9	
	.775	-50.0	
	.800	-21.1	
	.826	-13.8	
	.853	-14.0	
April 7.....	152.769	-37.7	
	.805	-14.4	
	.835	+ 1.3	
	.864	+11.7	
April 16.....	161.741	- 8.2	
	.770	+13.5	
	.802	-10.0	
	.833	-52.2	
	.858	-29.9	

* Pub. Dom. Obs. Vol. V, p. 303.

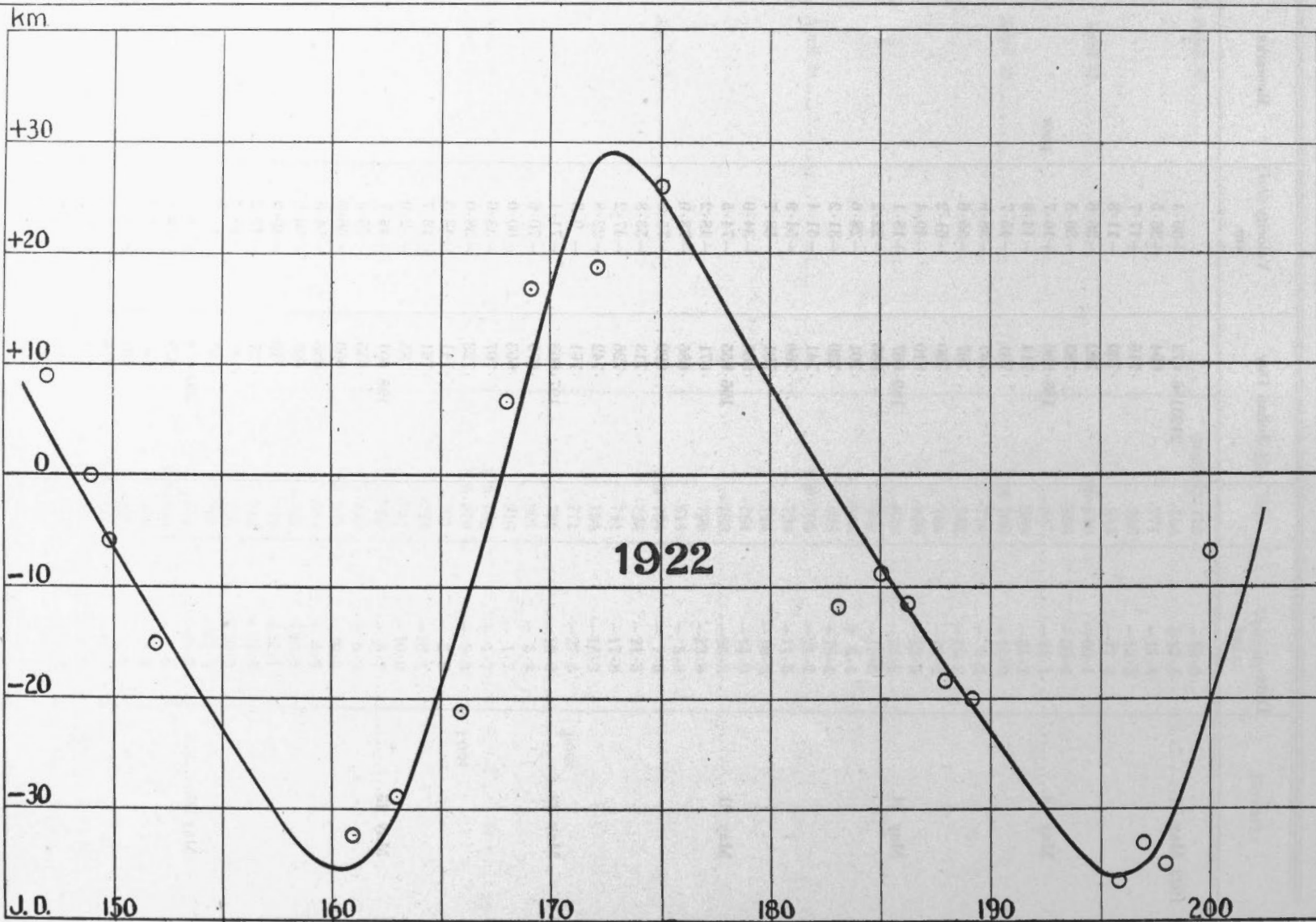
RADIAL VELOCITIES OF σ SCORPII—Continued

Date	Julian Day	Velocity km.	Remarks
1922 April 18.....	2423163.716	-19.0	
	.744	+17.4	
	.771	-11.4	
	.796	-42.3	
	.815	-47.5	
April 21.....	166.810	-60.1	
	.826	-50.4	
	.847	-54.1	
	.869	-31.2	
April 23.....	168.706	-10.0	
	.724	- 9.2	
	.743	-16.2	
	.766	-26.2	
	.789	-33.5	
	.812	-24.2	
	.835	-15.6	
	.858	+ 6.4	
	.878	+18.4	
April 24.....	169.703	-21.2	
	.724	-11.6	
	.744	-16.2	
	.764	-14.0	
	.783	-23.3	
	.799	-23.9	
	.814	- 5.3	
April 27.....	172.704	- 7.6	
	.724	-21.3	
	.741	-17.8	
	.756	-18.2	
	.771	-27.6	poor
	.785	-10.3	
	.801	- 5.8	
	.819	- 1.7	
April 28.....	173.788	+ 1.7	
April 30.....	175.679	- 8.3	poor
	.701	- 3.8	
	.724	-10.1	
	.747	-10.9	
	.769	+ 9.7	
	.792	+ 6.9	
May 8.....	183.665	-26.0	
	.684	+ 4.3	
	.701	+20.4	
	.719	+27.1	
	.740	+24.6	
	.760	+10.0	
	.778	-27.5	
	.794	-18.6	
May 10.....	185.658	- 7.6	
	.676	- 4.9	
	.694	+26.8	
	.710	+32.9	
	.726	+26.1	
	.744	- 3.3	
	.762	-13.8	
	.804	-44.3	
	.830	-38.5	

RADIAL VELOCITIES OF σ SCORPII—*Concluded*

Date	Julian Day	Velocity km.	Remarks
1922 May 11.....	2423186.672	+30.4	
	.694	+26.5	
	.716	+17.7	
	.739	-11.8	
	.762	-35.6	
	.783	-36.5	
May 13.....	188.696	+16.7	poor
	.714	-14.6	
	.731	-45.7	
	.747	-38.6	
	.767	-55.6	
	.790	-61.2	
	.810	-49.4	
May 14.....	189.667	+18.1	
	.685	-22.2	
	.701	-28.6	
	.720	-31.2	
	.741	-51.4	
	.760	-54.9	
	.781	-58.7	
	.803	-34.0	
May 21.....	196.655	-74.5	
	.671	-48.2	
	.685	-78.0	
	.699	-75.3	
	.713	-53.8	
	.726	-47.2	
	.742	-22.8	
	.761	- 9.3	
May 22.....	197.663	-71.1	
	.679	-70.6	
	.693	-60.0	
	.707	-38.0	
	.723	-38.0	
	.741	-43.5	
	.761	-13.7	
	.785	- 2.0	
May 23.....	198.601	-48.7	
	.653	-75.5	
	.669	-66.0	
	.683	-54.8	
	.697	-56.5	
	.710	-40.9	
	.727	-42.2	
	.747	-18.7	
	.767	-11.7	
May 25.....	200.658	-24.3	
	.672	-19.8	
	.686	-14.9	
	.701	- 4.8	
	.718	- 3.3	
	.738	+ 8.0	
	.760	+25.0	
	.783	+36.7	
	.807	+21.2	

σ SCORPII. RADIAL VELOCITY VARIATION OF CENTRE OF MASS



S.W. Nov. 1922.

The above velocities furnish a fairly large number of nearly complete velocity curves, which may be considered, within the limits of error, of constant amplitude. Their center-of-mass lines, if they might be called so, give the following radial velocities for the nights indicated.

VALUES OF CENTER-OF-MASS VELOCITY OBTAINED FROM SHORT-PERIOD CURVES

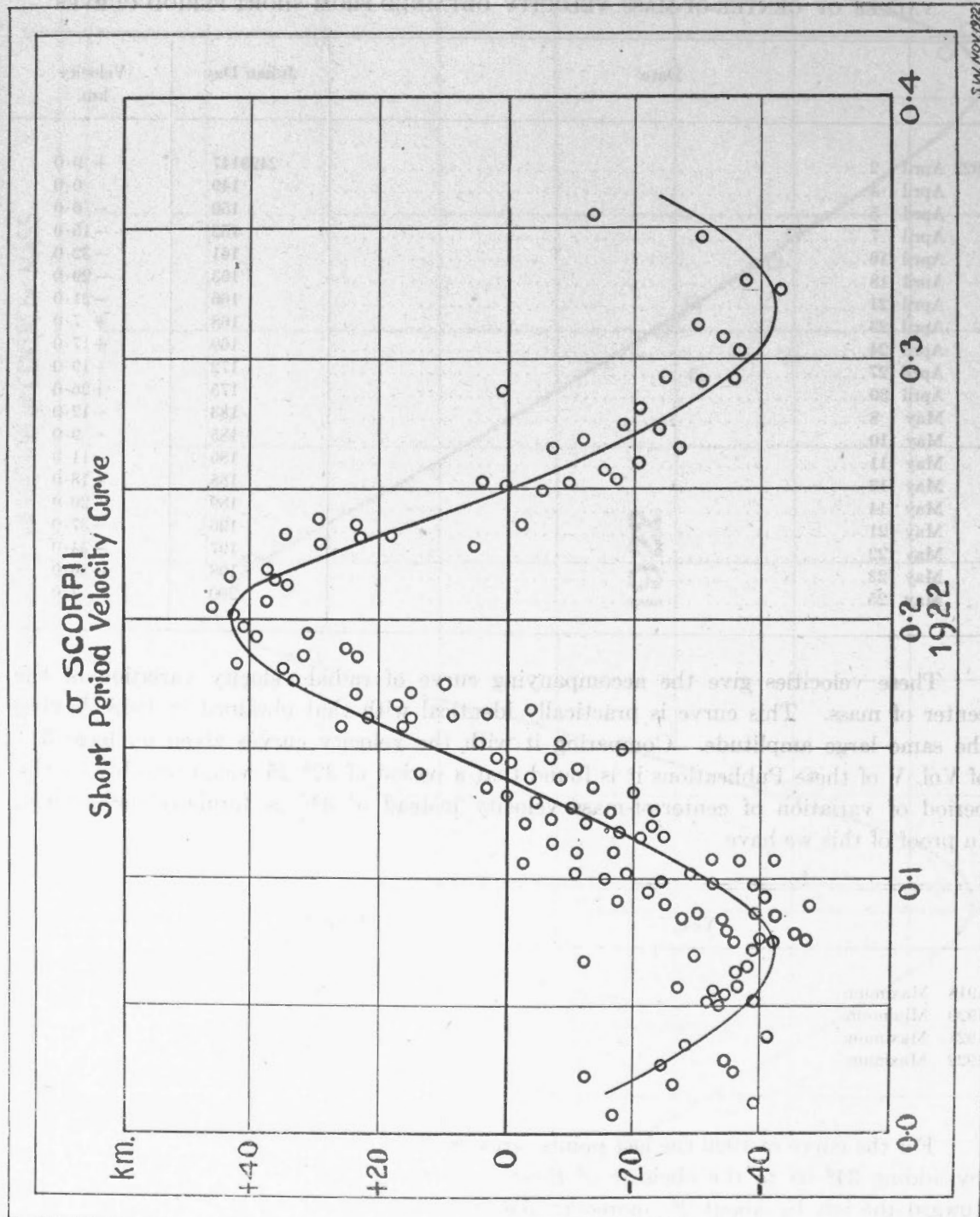
Date	Julian Day	Velocity km.
1922 April 2.....	2423147	+ 9.0
April 4.....	149	0.0
April 5.....	150	- 6.0
April 7.....	152	-15.0
April 16.....	161	-32.0
April 18.....	163	-29.0
April 21.....	166	-21.0
April 23.....	168	+ 7.0
April 24.....	169	+17.0
April 27.....	172	+19.0
April 30.....	175	+26.0
May 8.....	183	-12.0
May 10.....	185	- 9.0
May 11.....	186	-11.0
May 13.....	188	-18.0
May 14.....	189	-20.0
May 21.....	196	-37.0
May 22.....	197	-34.0
May 23.....	198	-36.0
May 25.....	200	- 7.0

These velocities give the accompanying curve of radial velocity variation of the center of mass. This curve is practically identical with that obtained in 1918, having the same large amplitude. Comparing it with the velocity curves given on page 311 of Vol. V of these Publications it is found that a period of $32^d.25$ would possibly be the period of variation of center-of-mass velocity instead of 34^d as formerly determined. In proof of this we have

Year	Julian Day	Equivalent
1918 Maximum.....	2421687	2421687
1920 Minimum.....	2461	$1687 + (24 \times 32.25)$
1921 Maximum.....	2816	$1687 + (35 \times 32.25)$
1922 Maximum.....	3171	$1687 + (46 \times 32.25)$

For the curve of 1920 the last points (crosses) have been derived from the first points by adding $34^d.08$ to the abscissae of these points; they will thus have to be displaced toward the left by about 2^d ; moreover the first point is probably too high so that the minimum of the curve would be close enough to J.D. 2422461. On the other hand the

values of the center-of-mass velocities derived from Selga's observations in 1915 do not seem to fit the period $32^d.25$, but do fit a period of $34^d.08$ much better, as was shown formerly*. To sum up, there seems to be a slight variation in the length of the long-period curve; the determination of such a variation, however, must await further observations.



* See residuals between the observed and computed velocities L.O.B. Vol. IX p. 173.

As to the short period of velocity variation, an examination of the table given on page 312 of Vol. V of these Publications shows that if the residuals of Obs-Pred are assumed to be constant the mean residual will be $-0^d.028$, so that, if the maximum of 1921 May 10, which happens at J.D. 2422820.646, is taken, it might be considered as a good origin to compute a value of the period by using the observations of 1922. It is found that the period $0^d.246828$ satisfies these observations. It is a shorter period, 0.246814 , which apparently connected the observations of 1920 with those of 1921.

For the observations of 1922 (computing the predicted maxima by adding $0^d.246828$ a certain number of times to J.D. 2422820.646) the following table is obtained:

Date	Observed Maximum J.D.	Predicted Maximum J.D.	Obs-Pred.
1922 April 2	2423147.932	.941	-0.009
April 4	149.925	.916	+0.009
April 5	150.900	.903	-0.003
April 7	152.872	.878	-0.006
April 16	161.769	.764	+0.005
April 18	163.740	.738	+0.002
April 21	166.940	.947	-0.007
April 23	168.915	.922	-0.007
April 24	169.888	.909	-0.021
April 27	172.882	.871	+0.011
April 30	175.840	.833	+0.007
May 8	183.723	.731	-0.008
May 10	185.713	.706	+0.007
May 11	186.687	.693	-0.006
May 13	188.661	.668	-0.007
May 14	189.650	.655	-0.005
May 21	196.800	.813	-0.013
May 22	197.800	.801	-0.001
May 23	198.779	.788	-0.011
May 25	200.777	.763	+0.014

The observations thus indicate that:

1. *The short period variation has decreased slightly from 1920 to 1921, this decrease being of the order of $0^d.000020$.*
2. *The short period variation has increased slightly from 1921 to 1922, this increase being of the order of $0^d.000014$.*

To sum up, there is an interesting small fluctuation of the short period, possibly of an amplitude of the order of $0^d.00004$.

Taking now the observations of 1922, we may superpose the different short-period velocity curves, so that all of them have the same but undetermined mean velocity. We then obtain the accompanying curve which most likely has a constant amplitude.

Detailed measures of a few spectrograms of σ Scorpii taken in 1920, 1921 and 1922 will now be given in order to give an idea of the value of these measures. The principal lines corresponding to the micrometer readings can be identified by using the table given in the article on δ Ceti*.

*Pub. Dom. Obs., Vol. V, p. 419.

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS

Plate 9063
1920 April 16.727

Reduced micrometer reading	Velocity km.	Weight
50.838	-79.1	2
58.415	-58.3	4
62.654	-43.2	6
63.390	-79.2	4

Weighted mean -60.5
 V_a +19.2
 V_d + 0.2
 Curv. - 0.3

Radial velocity -41.4

Plate 9064
1920 April 16.769

Reduced micrometer reading	Velocity km.	Weight
50.830	- 88.1	3
53.685	- 80.7	6
58.405	- 70.7	9
62.623	- 83.8	9
63.203	- 66.0	8
66.821	- 66.2	5
66.971	- 48.6	5
67.350	-105.0	7
68.568	- 25.6	4
76.311	- 58.8	2

Weighted mean -72.3
 V_a +19.1
 V_d + 0.1
 Curv. - 0.3

Radial velocity -53.4

Plate 9065
1920 April 16.785

Reduced micrometer reading	Velocity km.	Weight
46.802	-24.6	2
50.846	-70.1	5
53.675	-92.4	3
58.392	-86.8	8
62.656	-40.6	7
63.394	-73.9	8
66.990	-22.2	6
67.325	-32.0	4
76.327	-33.4	2

Weighted mean -57.2
 V_a +19.1
 V_d + 0.1
 Curv. - 0.3

Radial velocity -38.3

Plate 9066
1920 April 16.804

Reduced micrometer reading	Velocity km.	Weight
49.545	-76.6	2
50.839	-78.0	5
51.391	-68.9	4
53.704	-58.5	6
54.156	-77.2	6
58.403	-73.2	7
62.617	-91.7	2
63.392	-76.6	2
67.380	-63.0	2
76.309	-62.0	2

Weighted mean -71.9
 V_a +19.1
 V_d 0.0
 Curv. - 0.3

Radial velocity -53.1

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—Continued.

Plate 9067
1920 April 16·826

Reduced micrometer reading	Velocity km.	Weight
50·885	-26·0	1
58·394	-84·3	3
62·645	-55·0	2
63·415	-46·2	2
67·390	-49·0	2
76·344	- 6·4	1

Weighted mean -53·2
 Va +19·1
 Vd 0·0
 Curv. - 0·3

Radial velocity -34·4

Plate 9638
1921 May 16·700

Reduced micrometer reading	Velocity km.	Weight
34·237	-66·0	1
46·767	-62·1	2
49·566	-53·3	2
50·848	-67·8	2
51·500	-80·9	2
53·208	-63·8	2
53·697	-66·7	1
58·424	-47·1	6
62·650	-48·5	3
66·958	-66·7	1
70·201	-43·5	2
76·306	-66·8	1

Weighted mean -57·5
 Va + 5·8
 Vd + 0·1
 Curv. - 0·3

Radial velocity -51·9

Plate 9637
1921 May 16·669

Reduced micrometer reading	Velocity km.	Weight
50·869	-44·1	3
53·699	-64·4	4
54·126	-56·2	4
58·278	-24·8	6
58·428	-42·2	4
58·938	-60·0	1
62·637	-65·5	1
63·405	-59·4	1
64·533	-73·7	2
67·913	-12·7	2
76·326	-35·0	1

Weighted mean -45·7
 Va + 5·8
 Vd + 0·2
 Curv. - 0·3

Radial velocity -40·0

Plate 9639
1921 May 16·727

Reduced micrometer reading	Velocity km.	Weight
37·480	-62·4	1½
47·393	-15·1	1
50·862	-52·0	1
51·415	-41·8	2
51·528	-49·0	2
53·726	-32·8	2
58·428	-42·2	5
62·667	-26·2	2
64·809	-44·6	2
65·691	- 4·1	2
76·317	-49·3	1

Weighted mean -36·8
 Va + 5·8
 Vd 0·0
 Curv. - 0·3

Radial velocity -31·3

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—*Continued.*Plate 9640
1921 May 16.757

Reduced micrometer reading	Velocity km.	Weight
50.904	- 4.5	3
52.494	-13.8	3
53.746	- 9.4	3
55.281	-39.3	1
58.462	0.0	4
64.565	-30.8	4
64.825	-23.0	4
70.228	- 4.4	2
76.319	-46.1	1

Weighted mean -15.7
 V_a + 5.8
 V_d 0.0
 Curv. - 0.3

Radial velocity -10.2

Plate 9641
1921 May 16.785

Reduced micrometer reading	Velocity km.	Weight
46.262	+23.3	1
50.917	+10.2	1
58.453	-11.2	2
62.709	+28.8	2
63.812	+27.9	3
64.615	+36.2	2
67.379	+43.1	1
70.230	- 1.4	1
76.333	-23.8	1

Weighted mean +17.3
 V_a + 5.7
 V_d - 0.1
 Curv. - 0.3

Radial velocity +22.6

Plate 10560
1922 April 23.706

Reduced micrometer reading	Velocity km.	Weight
45.299	-43.0	1
46.198	-44.5	1
46.847	-23.5	2
50.861	-53.1	3
53.729	-29.3	6
55.312	- 2.4	1
58.438	-29.8	5
58.986	0.0	1
62.690	+ 3.9	2
63.459	+11.9	3
63.724	-89.1	1
67.388	-51.8	2
70.220	-15.9	3

Weighted mean -26.4
 V_a +16.5
 V_d + 0.2
 Curv. - 0.3

Radial velocity -10.0

Plate 10561
1922 April 23.724

Reduced micrometer reading	Velocity km.	Weight
37.531	-13.4	1
45.323	-17.8	1
49.411	-52.2	1
50.848	-67.8	2
53.740	-16.4	4
58.431	-38.4	5
58.957	-36.3	3
62.685	- 2.6	2
63.434	-21.1	1
70.240	+13.1	3
76.329	-30.2	3

Weighted mean -25.5
 V_a +16.5
 V_d + 0.1
 Curv. - 0.3

Radial velocity - 9.2

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—Continued.

Plate 10562
1922 April 23.743

Reduced micrometer reading	Velocity km.	Weight
34.250	-53.9	1
35.768	-29.1	3
37.509	-34.6	3
45.298	-44.1	1
48.593	-42.9	3
49.590	-26.6	1
50.889	-21.5	7
52.465	-47.1	2
53.724	-35.1	6
55.283	-36.9	3
58.431	-38.4	7
58.953	-41.3	3
62.665	-28.8	4
63.439	-14.5	3
66.848	-29.0	1
67.011	+ 6.9	1
67.368	-27.8	2
70.204	-39.2	3
76.329	-30.2	2

Weighted mean -32.5
 Va +16.5
 Vd + 0.1
 Curv. - 0.3

Radial velocity -16.2

Plate 10563
1922 April 23.766

Reduced micrometer reading	Velocity km.	Weight
31.700	-23.4	1
32.207	-34.6	1
33.250	-39.6	1
35.759	-37.6	2
37.482	-60.5	3
46.202	-40.3	2
48.565	-73.7	1
49.566	-53.3	3
50.866	-47.5	6
51.415	-41.8	1
52.462	-50.6	2
53.713	-48.0	5
58.429	-40.9	9
62.676	-14.4	3
63.432	-23.8	3
66.976	-41.7	2
76.315	-52.5	1

Weighted mean -42.5
 Va +16.5
 Vd + 0.1
 Curv. - 0.3

Radial velocity -26.2

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—*Continued.*

Plate 10564
1922 April 23.789

Reduced micrometer reading	Velocity km.	Weight
35.722	-72.4	2
40.874	-56.0	2
45.307	-34.6	1
46.211	-30.7	3
48.581	-56.1	2
49.423	-38.8	2
49.581	-36.6	3
50.864	-49.7	6
52.455	-58.6	2
53.703	-59.7	8
55.267	-55.9	1
58.417	-55.8	10
58.958	-35.0	4
62.658	-38.0	5
63.421	-38.3	3
70.181	-72.5	2
76.316	-50.9	2

Weighted mean -49.7
 Va +16.5
 Vd 0.0
 Curv. - 0.3

Radial velocity -33.5

Plate 10565
1922 April 23.812

Reduced micrometer reading	Velocity km.	Weight
28.040	-39.2	1
31.684	-37.8	2
32.186	-53.7	2
33.262	-28.5	3
34.247	-56.7	1
35.720	-74.3	1
40.558	-60.0	2
40.868	-62.0	1
45.304	-37.8	2
46.171	-73.1	1
49.410	-53.3	2
50.857	-57.6	5
51.421	-35.0	2
52.475	-35.6	3
53.716	-44.5	8
55.280	-40.5	2
58.423	-48.4	5
58.944	-52.5	4
62.675	-15.7	4
63.437	-17.2	3
63.759	-42.6	2
64.576	-16.1	1
65.080	-27.0	1
67.350	+ 2.8	1
67.894	-38.1	1
68.570	-22.7	2
70.211	-29.0	1
76.334	-22.3	2

Weighted mean -40.4
 Va +16.5
 Vd 0.0
 Curv. - 0.3

Radial Velocity -24.2

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—*Continued.*

Plate 10566
1922 April 23·835

Reduced micrometer reading	Velocity km.	Weight
37·516	-27·8	1
45·307	-34·6	1
46·789	-38·5	2
49·604	-11·1	3
50·876	-36·2	4
52·477	-33·3	3
53·722	-37·4	6
56·579	-18·2	2
58·127	-1·2	2
58·430	-39·7	5
58·946	-50·0	2
62·674	-17·0	4
63·405	-59·4	3
64·809	-44·5	1
70·220	-16·0	3
76·320	-44·5	1

Weighted mean -31·7
 Va +16·4
 Vd 0·0
 Curv. - 0·3

Radial velocity -15·6

Plate 10567
1922 April 23·858

Reduced micrometer reading	Velocity km.	Weight
41·690	+17·2	1
46·852	+28·9	2
50·874	-38·4	1
53·733	-24·6	4
55·288	-30·9	1
58·448	-17·4	6
58·785	+11·2	1
58·968	-22·5	2
62·675	-15·7	4
63·463	+17·2	3
67·004	- 2·8	2
67·348	0·0	2
70·230	- 1·4	2
76·313	-55·6	1

Weighted mean - 9·6
 Va +16·4
 Vd - 0·1
 Curv. - 0·3

Radial velocity + 6·4

DETAILED MEASURES OF SOME OF THE SPECTROGRAMS—*Concluded.*

Plate 10568
1922 April 23·878

Reduced micrometer reading	Velocity km.	Weight
45·348	+ 8·4	2
46·220	-21·2	2
50·914	+ 6·8	3
53·702	-60·8	1
55·303	-13·1	2
58·470	+ 9·9	6
58·773	- 3·7	2
62·674	-17·0	3
63·467	+22·4	3
67·034	+38·9	2
70·245	+20·3	1
76·347	- 1·6	2

Weighted mean + 2·4
 V_a +16·4
 V_d - 0·1
 Curv. - 0·3

Radial velocity +18·4

All qualities of spectrograms obtained are represented in the measures given.

DOMINION OBSERVATORY,
 OTTAWA,
 November 29, 1922.