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THE NEW STAR IN THE CONSTELLATION AQUILA

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The telegraphic announcement of a new star in Aquila was received here on June 9, 1918, and communicated to the writer on the afternoon of the same date. It was cloudy here the previous evening when the star was discovered by so many observers in Europe and the United States, but, fortunately, a good proportion of the nights during the remainder of June and the month of July were clear, or partly so, so that a good series of spectrograms were secured during this time when the star was changing rapidly in brightness and in the character of its spectrum. On 35 nights during June and July it was spectrographed using the single-prism instrument, having a dispersion of 33·5 angstroms per millimètre at $H\gamma$ and covering the region roughly from λ 3850 to λ 5030. Seed 27 plates were used in all but a few instances. After the end of July it was not felt necessary to photograph so often, since the changes were taking place more leisurely, and plates were secured on only 19 nights from that time up to the date of the last observation on December 17. Altogether about 140 spectra were made.

From a star of approximately the 11th magnitude on June 5 it rose to one of magnitude − 1·5 on June 9, thus increasing in brightness nearly 100,000-fold in four days. The increase may have been still more rapid as there is no authentic record of it on the 6th. From its maximum brilliancy on the 9th it rapidly diminished in brightness until about the 29th of June when its magnitude was 3·8. It then began to oscillate in brightness though gradually tending to become fainter. These variations will be better established when the definite light curve is issued by Harvard, but for the present approximate results which are the means of four observers, Messrs. Stewart, DeLury, Pearce and the writer, will be used. Minima occurred on June 29, July 11, July 22, August 3, August 14 and August 23; while maxima fell around July 3, July 15, July 27, August 8, August 18 and August 27, the average period being 11 days and the range of variation about $0 \cdot 6^{m}$. The time required for the star to pass from a minimum to a maximum was on the average only two-thirds the time required for it to fall from a maximum to the next minimum. Cepheid variables are also characterized by a more rapid rise than decline and this

resemblance, while it should not be strained, should nevertheless be noted. It should also be noted that the photographic records of the star, which give its history back as far as 1888, show it to have been variable over a range of at least 2 magnitudes. In the case of Nova Persei (1901) the oscillations in brightness began about the same length of time after maximum brilliancy, but their period was much shorter and the range much greater. The average range was $1 \cdot 5^m$ accomplished in a period of roughly 3 days and these oscillations continued for about 100 days.

At the end of August the star was about $4 \cdot 5^m$ and through September diminished with smaller oscillations to a little brighter than $5 \cdot 0^m$, which brightness it maintained through October and November, decreasing to between $5 \cdot 5^m$ and $6 \cdot 0^m$ by the middle of December. In the table which follows, the estimates of brightness were made by comparing the nova with surrounding stars using their magnitudes as given in *Harvard Annals*, Vol. 50. For the first two nights, comparison was made principally with Vega and a correction should have been made for the different zenith distances but such has not been done. When the star became fainter it was possible to select stars of about the same zenith distance, thereby doing away with the necessity of considering this factor. The star field issued by Harvard College Observatory in Bulletin 661 was found very convenient in making the estimations of brightness. When the star became fainter than the 4th magnitude it is possible that our estimations were vitiated by the light from the $6 \cdot 26^m$ star, 17 minutes of arc, to the northeast. While the nova was of the 4th magnitude, or brighter, the additional light of this star would never cause more than $0 \cdot 1^m$ of a difference, but as the nova became fainter the light from the nearby star would have an increasing influence on the combined brightness amounting to $0 \cdot 3^m$ when the nova was of 5th magnitude. On certain nights, while the star was of about this brightness, the nova had a fuzzy appearance and, while ordinarily at Ottawa a $6 \cdot 26^m$ star can not be seen with the unaided eye, its blended light may have been the cause of the peculiar blurred appearance. In any event no allowance was made for its effect; the combined light was recorded. For these and other reasons the magnitudes given are not claimed to be exact, but the means, which are given to tenths only, should be close approximations and after the first few days should not be in error much over $0 \cdot 2^m$ at the outside. One instance will show that small variations can be detected by the unaided eye. One night the star was midway in brightness between two stars on either side of it in the sky, δ Aquilæ ($3 \cdot 44^m$) and η Serpentis ($3 \cdot 42^m$), and while either one or both may be in error or may be variable in light it is not likely that the difference would amount to more than $0 \cdot 2^m$, and there was no doubt about saying that the nova was brighter than δ Aquilæ and fainter than η Serpentis. On June 25 also in my notes is entered "η Serpentis, type K, certainly appears brighter than δ Aquilæ, type F."

NAKED EYE ESTIMATES OF MAGNITUDE OF NOVA AQUILÆ No. 3

	Harper	DeLury	Pearce	Stewart	Means
1918					
June 9·6	−0·4				−0·4
" 10·6	0·2				+0·2
" 13·6	1·5				1·5
" 14·6	1·8				1·8
" 15·6	1·5	1·4			1·5
" 17·6	2·2	1·4			1·8
" 18·6	2·3				2·3
" 19·6	2·5				2·5
" 20·6	2·6				2·6
" 23·6	2·8				2·8
" 25·6	3·2	3·2			3·2
" 26·6	3·6	3·6			3·6
" 28·6		4·0			4·0
" 29·6	3·8	3·9			3·8
July 2·6	3·4		3·2	3·2	3·3
" 3·6	3·2	3·1		3·4	3·2
" 4·6	3·4	3·3		3·3	3·3
" 5·6	3·5				3·5
" 9·6	3·7	3·6		3·7	3·7
" 10·6	4·1	4·0		3·8	4·0
" 11·6	4·1	3·9	4·1		4·0
" 12·6	4·1	4·0	4·1	4·1	4·1
" 13·6	3·9	3·7	3·9	3·9	3·9
" 14·6	3·8	3·8	3·6		3·8
" 15·6	3·8	3·9	3·6	3·8	3·8
" 17·6	3·8	3·9	3·6	3·7	3·7
" 18·6	3·9	3·8		3·7	3·8
" 19·6	4·0	3·9	4·0		4·0
" 20·6	4·1	3·9			4·0
" 21·6	4·3		4·5		4·4
" 24·6			4·1		4·1
" 25·6			3·9		3·9
" 26·6	4·1		3·9		4·0
" 27·6	4·0	3·9	3·9		3·9
" 28·6	4·0	4·0	3·9	3·9	4·0
" 30·6	4·1	4·0	4·0	4·0	4·0
" 31·6	4·2	4·1	4·2	4·0	4·1
Aug. 1·6	4·4	4·4	4·3		4·4
" 2·6	4·3	4·6	4·7	4·5	4·5
" 4·6	4·4				4·4
" 5·6	4·6				4·6
" 6·6	4·2	4·1			4·2
" 7·6	4·0		3·9		4·0
" 9·6	4·1		4·3	4·0	4·1
" 10·6	4·2	4·1			4·2
" 11·6	4·3	4·2	4·5		4·3
" 12·6	4·4	4·2			4·3
" 13·6	4·5	4·5	4·7		4·6
" 14·6	4·6		4·7		4·6
" 15·6	4·7				4·7
" 16·6	4·5		4·5		4·5
" 17·6	4·3	4·5			4·4
" 18·6	4·3		4·3		4·3
" 19·6	4·4		4·5		4·4
" 20·6		4·4	4·7		4·6
" 21·6	4·3	4·4	4·9		4·6

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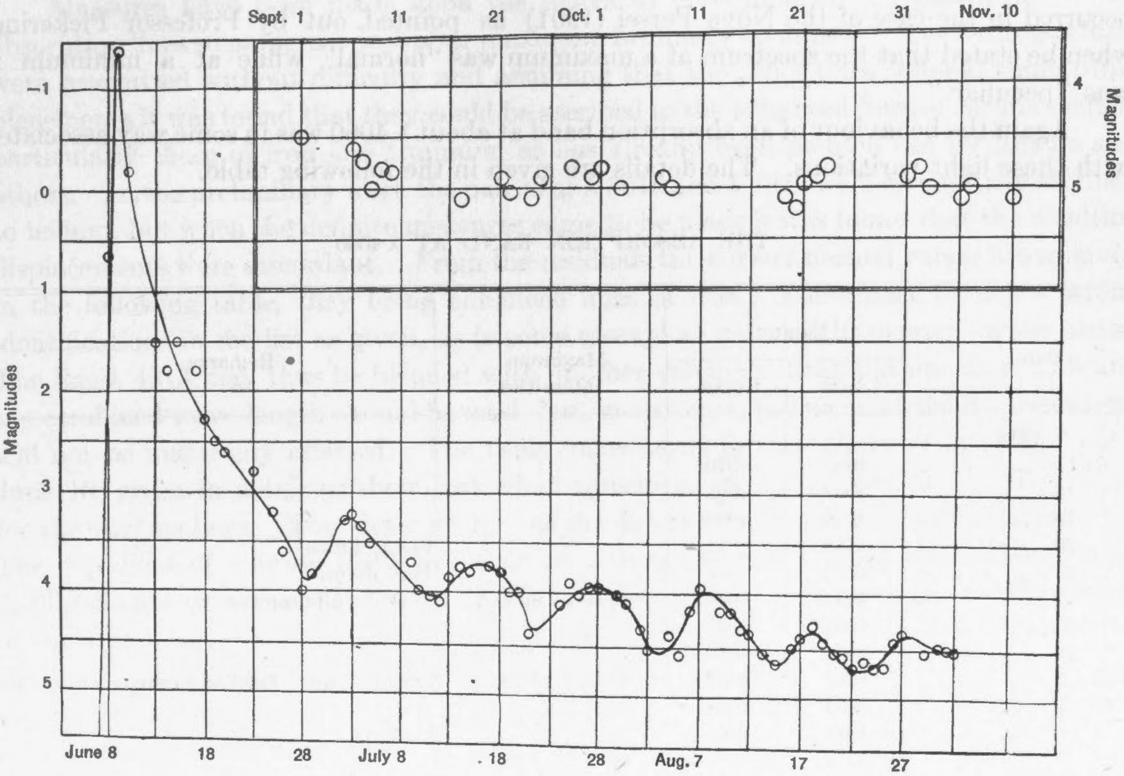
NAKED EYE ESTIMATES OF MAGNITUDE OF NOVA AQUILÆ No. 3—*Concluded*

	Harper	DeLury	Pearce	Stewart	Means
Aug. 22·6			4·7		4·7
" 23·6	4·6		4·7		4·6
" 24·6	4·6	4·6	4·8		4·7
" 25·6	4·6	4·6	4·9		4·7
" 26·6	4·5	4·4	4·6	4·4	4·5
" 27·6	4·4			4·3	4·4
" 29·6	4·5			4·6	4·6
" 30·6	4·6	4·4			4·5
" 31·6		4·5			4·5
Sept. 1·6		4·5			4·5
" 6·6		4·5	4·7		4·6
" 7·6	4·8	4·5	4·9		4·7
" 8·6			5·0		5·0
" 9·6	4·8	4·6	4·9		4·8
" 10·6	4·8	4·7	4·9	4·9	4·8
" 17·6	5·0	5·0	5·3		5·2
" 21·6	4·9	4·5			4·7
" 22·6	4·9	4·6	5·2		4·9
" 24·6	5·1	4·7	5·4		5·1
" 25·57	4·9				4·9
" 28·54	4·8				4·8
" 30·59	4·9				4·9
Oct. 1·56	4·8				4·8
" 3·57	5·0				5·0
" 7·62	4·9				4·9
" 8·59	5·0				5·0
" 19·5	5·1 (4-inch)				5·1
" 20·		5·2			5·2
" 21·5	4·9	5·0			5·0
" 22·52	4·9				4·9
" 23·58	4·8				4·8
" 31·54	4·9				4·9
Nov. 1·52	4·8				4·8
" 2·48	5·0				5·0
" 5·50	5·1				5·1
" 6·		5·0			5·0
" 10·49	5·1				5·1
Dec. 1·48	5·2				5·2
" 10·48	5·7 (4-inch)				5·7
" 17·48	5·8 (4-inch)				5·8
1919*					
Feb. 10·95	6·1 (4-inch)				6·1
" 19·91	6·4 (4-inch)				6·4
Mar. 13·92	6·8 (4-inch)				6·8

*Added while going through the press.



Estimated Magnitudes of Nova Aquilæ No. 3

The spectrum on June 9 was of a continuous nature with broad absorption lines due principally to hydrogen. The next night showed the characteristic "nova" type of spectrum, the broad emission bands appearing and being flanked on their violet edges by pairs of absorption lines. Numerous other absorption lines were shown, as may be seen from an accompanying table. This persisted for a couple of nights, when the continuous spectrum weakened and the fainter of the absorption lines were lost. With their disappearance the emission band at λ 4640 began to make its appearance, being fairly noticeable on the 14th and becoming equally prominent with the hydrogen emissions before the end of the month. The nebular emission N_1 (λ 5007) seems to show first about June 18. The other nebulium bands λ 4686, λ 4363 and λ 4959 developed later in the order given, λ 4686 being seen at the minimum June 29, it and λ 4363 at minimum on July 11, while λ 4959 developed a few days later, though remaining very weak till the end of July. Since then the light from the star has been almost wholly emissive in character, with the general tendency for the nebular and λ 4640 emissions to equal in intensity those of hydrogen. A more detailed description is given later.

In connection with the variations in brightness it may be pointed out here, that every increase of brightness was accompanied by a return of the continuous spectrum which in turn faded as the star diminished in brightness. This is similar to what occurred in the case of the Nova Persei (1901) as pointed out by Professor Pickering, when he stated that the spectrum at a maximum was "normal" while at a minimum it was "peculiar."

Again the behaviour of an absorption band at about λ 4060 was in some way associated with these light variations. The details are given in the following table.

THE ABSORPTION BAND AT λ 4060

Date	Limits		Maximum Intensities	Remarks
	Lower	Upper		
1918				
June 17	4058	4070		
" 18	4062	4068		
" 19	4056	4068		
" 20	4058	4071		Faint, diffuse
" 23	4053	4066		Very diffuse
" 25	4051	4064	4054·7 4059·7	Very definite centres
" 26	4062	4075		
" 29	4064	4075		
July 2	4049	4064	4053 4060	Definite limits, indefinite centres
" 3	4054	4067		
" 4	4051	4064		Uniform
" 5	4054	4066	4057·1 4062·1	
" 6	4054	4066		Red edge diffuse
" 9	4046	4053		Usual band absent, new one
" 10	4062	4075		Tendency 4048 also
" 11	4046	4075		Slight break between merged bands
" 12	4065	4075		Faint, diffuse; band 4048 suspected
" 13	4046	4054		Faint diffuse band
" 14	4049	4053		Narrow defined band
" 15	4050	4054		
" 17	...	...	4051·4 4058·0	Intense lines, violet stronger
" 18	4046	4049		Not pronounced
" 19	4062	4076		Centres possible at 4048, 4053
" 20	4065	4074		Not pronounced
" 21	4068	4074		
" 25	4065	4073		Very faint, suspect 4048
" 26	4063	4077		Very faint
" 30	4064	4076		4045-4052, both diffuse
" 31	4063	4074		4046-4052, both diffuse
Aug. 1	4068	4075		

Comparing the data with the light curve, it would appear that the band seems to shift to the red at a minimum and in the opposite direction during a maximum, that is, that different absorption lines or series of lines are present in the two cases. The rule does not hold definitely, but seems to fit the case most of the time. Thus, during the two minima, June 26 to 29 and July 10 to 12, the band is to be read from λ 4063 to λ 4075, while at the maximum, July 2 to 6, it is at λ 4052 to λ 4065. July 9 seems to be a transition date with the former band absent and a new one at λ 4048 showing. Former novæ have been characterized by somewhat similar behaviour of this band, and the combined data should establish some definite connection between the quantity and quality of light.

Measures have been made upon the plates to determine the displacements of the absorption lines so numerous just after maximum brilliancy on June 9. The hydrogen lines were recognized without difficulty and assuming that the other lines suffered similar displacements it was found that they could be ascribed to the enhanced lines of certain metals, particularly those of iron and titanium, as has already been pointed out by Adams and others. In the preliminary work the pair near λ 5016 and λ 4922 were erroneously ascribed to helium, but when the definite measures came to be made it was found that the resulting displacements were discordant. From the residuals the correct normal values are as given in the following table, they being enhanced lines of iron. There may be a few wrong identifications in the list as given, as in some cases close pairs might overlap on our plates. The line λ 4313 may thus be blended with another enhanced titanium line at λ 4315 and the combined wave-length should be used, but, in any case, the mean of the displacements will not be materially affected. The table following is for the plates of one night only, June 10, given in detail to show just what agreement existed among the displacements for the various lines. The measures for the displacements on other dates follow later on. The expedient of quoting them as velocities is used, though it is not implied that these displacements are necessarily due to velocities of outrushing gases, much less to the velocity of the star itself. A summary follows for the other dates. The velocities obtained for the sharp calcium lines, *H* and *K*, show that within the limits of error they are constant and have a mean value of $-19 \cdot 9$ km. $\pm 0 \cdot 7$ km. per second. This may be looked upon as the velocity of the nova relative to the sun. The nova is 31° 22′ distant from the point in the heavens toward which the solar system is moving and, if we remove the component due to this motion, we have a velocity of $-2 \cdot 8$ km. per second for the nova with reference to the stellar system, so that we may consider it as approximately at rest with reference to the stellar system.

LINE DISPLACEMENTS ON JUNE 10, 1918

λ	Element	8554 b		8555		8556 a		8556 c	
		Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
5018·629	*Fe*	−1432	¼	−1439	½	−1424	½	−1436	½
4924·115	*Fe*	1422	1	1449	½	1399	½	1433	½
4824·33	*Fe-Cr*	1440	¼	1466	¼	1439	¼	1439	¼
4584·018	*Fe*	1424	¼	1451	½	1482	¼		
4572·156	*Ti*	1433	¼	1440	½	1449	¼	1450	¼
4563·939	*Ti*	1454	¼			1460	¼	1436	¼
4549·766	*Fe-Ti*	1426	½	1434	½	1414	¼	1430	¼
4534·139	*Ti*	1449	¼	1351	¼	1421	¼	1368	¼
4522·871	*Fe*	1481	¼	1479	¼	1466	¼		
4515·508	*Fe*					1502	¼		
4508·455	*Fe*	1440	¼			1415	¼		
4501·448	*Ti*	1420	¼	1411	½	1456	¼	1459	¼
4481·400	*Mg*	1450	¾	1433	½	1438	½	1418	½
4443·976	*Ti*	1467	½	1445	½	1457	¼	1458	½
4417·88	*Ti*	1502	¼	1480	¼				
4404·927	*Fe*	1479	¼						
4399·94	*Ti-Cr*	1446	¼			1451	¼	1455	¼
4395·286	*Ti*	1483	¼			1466	¼		
4385·55	*Fe*	1501	¼	1494	½	1472	¼	1505	¼
4352·006	*Fe-Mg*	1439	¼						
4320·992	*Ti*	1478	¼	1417	¼	1487	¼	1475	¼
4313·034	*Ti*	1344	¼	1384	¼	1387	¼	1389	¼
4308·081	*Fe*	1452	½						
4300·211	*Ti*	1403	¼	1405	½	1387	¼	1390	½
4294·301	*Ti*							1483	¼
4289·915	*–Ti*	1459	¼						
4246·996	*Sc*	1456	½	1469	½	1468	½	1471	¼
4233·328	*Fe*	1451	½	1454	½	1458	½	1466	¼
4226·40	*Ca, Cr, Ti*	1441	¼	1429	½	1430	½	1459	¼
4215·668	*Sr–*	1483	½	1477	½	1500	¼	1482	½
4163·80	*Ti*	1487	¼	1483	½	1476	¼	1476	½
4077·885	*–Sr*	1490	¼	1496	¼	1481	¼	1476	¼
4071·901	*Fe*	1461	¼	1459	¼				
4063·756	*Fe*	1486	¼			1498	¼		
4045·975	*Fe*	1510	¼	1484	½	1497	¼		
3933·825	*Ca*	1408	¼	1444	¼			1473	¼
4861·527	*H*	1374	½	1375	½	1371	½	1373	½
4340·634	*H*	1350	½	1353	½	1345	½	1385	¼
4101·890	*H*	1363	½	1372	½	1378	½	1396	¼
3970·177	*H*	1346	¼	1425	¼	−1432	¼	1379	¼
3889·150	*H*	−1308	¼	−1320	¼			−1384	¼
Means		−1436·2		−1433·8		−1437·0		−1436·7	
Reduction to Sun		+ 10·3		+ 10·3		+ 10·3		+ 10·3	
Displacement		−1425·9		−1423·5		−1426·7		−1426·4	

Thus, taking the mean of the four, we have a line displacement to the violet on June 10th corresponding to a velocity of 1425·6 km. This represents a displacement at H_β of 23·1 angstroms, at H_γ of 20·6 angstroms, at H_δ of 19·5 angstroms, and at H_ϵ of 18·9 angstroms. I have purposely separated the five hydrogen lines, placing them at the end of the above table, as their displacements seem to be less than those of the metallic lines.

The displacements, relative to the sun, of the metallic lines alone, are respectively 1440, 1436, 1440 and 1437 km., while corresponding figures for the hydrogen lines are 1343, 1358, 1364 and 1370 km., an average difference of 79 km., or more than one angstrom unit. Even allowing for the uncertainty of setting on these broad lines, the discrepancy seems to be real and must have some physical interpretation.

Besides the 41 lines in the above table there were others measured with similar displacements, but being of poorer quality they were not included. With identifications given where possible they are as follows.

λ	Element	λ	Element
5052·2	....	4154·2	....
4588·38	*Cr*	4053·98	*Ti-Fe*
4374·98	*Ti*	4025·29	*Ti*
4221·9	....	4004·6	....
4179·03	*Fe*	3913·61	*Ti*
4173·27	*Ti-Fe*	3910·4	....

The foregoing measurements relate to the set of lines which suffered the least displacement. But as already stated there were in general two sets of lines for those lines appearing on the plates of the preceding evening. The displacements of the other members of the pair are as given in the following table.

λ	Element	8554 b		8555		8556 a		8556 c	
		Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
5018·629..............	*Fe*	−2226	$\frac{1}{4}$	−2191	$\frac{1}{2}$	−2235	$\frac{1}{4}$	−2255	$\frac{1}{2}$
4924·115..............	*Fe*	2213	$\frac{1}{2}$	2183	$\frac{1}{2}$	2191	$\frac{1}{4}$	2162	$\frac{1}{4}$
4861·527..............	$H\beta$	2206	$\frac{1}{4}$	2240	$\frac{1}{2}$	2223	$\frac{1}{4}$	2240	$\frac{1}{4}$
4481·400..............	*Mg*	2253	$\frac{1}{4}$	2244	$\frac{1}{2}$	2265	$\frac{1}{4}$	2190	$\frac{1}{4}$
4340·634..............	$H\gamma$	2225	$\frac{1}{4}$	2188	$\frac{1}{4}$	2206	$\frac{1}{4}$	2146	$\frac{1}{4}$
4101·890..............	$H\delta$	2210	$\frac{1}{2}$	2214	$\frac{1}{4}$	−2225	$\frac{1}{4}$	2210	$\frac{1}{4}$
3970·177..............	$H\epsilon$	2211	$\frac{1}{2}$	−2221	$\frac{1}{4}$	....	......	2213	$\frac{1}{4}$
3933·825..............	*Ca*	−2222	$\frac{1}{4}$	....	......	....	......	−2206	$\frac{1}{4}$
Means..........................		−2218·2		−2212·6		−2224·2		−2208·4	
Reduction to Sun................		+ 10·3		+ 10·3		+ 10·3		+ 10·3	
Displacement....................		−2207·9		−2202·3		−2213·9		−2198·1	

The mean of these four displacements, − 2205·6, corresponds to a shift to the violet at H_β of 35·8 angstroms, at H_γ of 31·9 angstroms, at H_δ of 30·2 angstroms, and at H_ϵ of 29·2 angstroms.

SUMMARY OF ABSORPTION LINE DISPLACEMENTS

Plate	Date, G.M.T.	Series 1		Series 2		Calcium *H* and *K*	
		Vel.	*n*	Vel.	*n*	Vel.	Wt.
	1918						
8543	June 9·668	−1266	8	...	...	−23·2	1¼
8545	" 9·681	1267	6	...	...	...	...
8546	" 9·683	1239	6	...	...	26·4	¾
8549	" 9·722	1288	6	...	...	14·8	¾
8550	" 9·815	1237	4	...	...	...	...
8551	" 9·832	1240	8	...	...	24·2	1
8551	" 9·836	1239	7	...	...	21·8	1
8554	" 10·674	1426	39	−2208	8	12·1	2¼
8555	" 10·681	1424	30	2202	7	23·9	1½
8556	" 10·691	1427	32	2214	6	23·8	1
8556	" 10·700	1426	28	2198	8	17·2	1¾
8559	" 13·723	1588	12	2308	4	13·3	1
8561	" 13·756	1588	15	2360	3	21·7	2
8572	" 14·711	1663	7	2368	4	23·3	1¼
8568	" 15·711	1682	8	−2281	4	21·2	1
8575	" 17·666	1735	5	...	...	15·5	1½
8585	" 18·810	1728	4	...	...	15·5	1¾
8588	" 19·734	1746	5	...	...	22·7	1¼
8589	" 20·595	1739	2	...	...	...	...
8590	" 20·642	1739	3	...	...	...	...
8596	" 25·734	1760	4	...	...	19·2	1½
8603	July 2·661	1671	3	...	...	24·2	1½
8605	" 3·670	1667	3	...	...	−25·0	¾
8607	" 4·618	1679	3	...	...	...	...
8609	" 5·694	1667	3	...	...	...	...
8612	" 9·710	1682	1	...	...	...	...
8618	" 13·723	1688	2	...	...	...	...
8619	" 14·645	1693	2	...	...	...	...
8620	" 15·652	1687	2	...	...	...	...
8621	" 17·630	1695	2	...	...	...	...
8623	" 18·597	1688	1	...	...	...	...
8624	" 18·644	−1705	1	...	...	...	...

MEASURES OF NOVA AQUILÆ NO. 3

λ	8543		8546		8545		8549 a		8550 b		8551 a		8551 b	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
5018·629	−1298	$\frac{1}{4}$	−1211	$\frac{1}{4}$	−1275	$\frac{1}{4}$	−1285	$\frac{1}{4}$	....	....	−1224	$\frac{1}{4}$	−1235	$\frac{1}{4}$
4924·115	1302	$\frac{1}{2}$	1232	$\frac{1}{4}$	1255	$\frac{1}{4}$	1322	$\frac{1}{2}$	−1168	$\frac{1}{8}$	1273	$\frac{1}{4}$	1253	$\frac{1}{4}$
4861·527	1307	$\frac{1}{4}$	1308	$\frac{1}{2}$	1311	$\frac{1}{2}$	1317	$\frac{1}{2}$	1296	$\frac{1}{2}$	1296	$\frac{1}{2}$	1239	$\frac{1}{2}$
4340·634	1296	$\frac{1}{2}$	1214	$\frac{1}{2}$	1279	$\frac{1}{4}$	1290	$\frac{1}{2}$	1231	$\frac{1}{2}$	1244	$\frac{1}{2}$	1238	$\frac{1}{2}$
4101·890	1247	$\frac{1}{2}$	1229	$\frac{1}{2}$	1264	$\frac{1}{2}$	1285	$\frac{1}{2}$	−1220	$\frac{1}{4}$	1206	$\frac{1}{4}$	1246	$\frac{1}{2}$
3970·177	1257	$\frac{1}{4}$	−1300	$\frac{1}{4}$	....	....	−1257	$\frac{1}{8}$	....	....	1264	$\frac{1}{2}$	1244	$\frac{1}{4}$
3933·825	1269	$\frac{1}{4}$	....	....	−1267	$\frac{1}{4}$	....	....	....	....	1264	$\frac{1}{4}$	−1319	$\frac{1}{4}$
3889·150	−1178	$\frac{1}{8}$	....	....	....	....	....	....	....	....	−1176	$\frac{1}{4}$	....	....
Weighted mean	−1277·10		−1249·48		−1276·99		−1250·30		−1247·13		−1250·10		−1249·70	
V_a	+ 10·95		+ 10·95		+ 10·95		+ 10·95		+ 10·95		+ 10·95		+ 10·95	
V_d	+ 0·19		+ 0·17		+ 0·17		+ 0·11		− 0·09		− 0·13		− 0·13	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·43		− 0·28		− 0·28	
Radial Velocity	−1266·2		−1238·6		−1266·1		−1239·5		−1236·7		−1239·7		−1239·3	

λ	8559 b		8561 a		8572 b		8568 a		8575 a		8585		8588	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
5018·629	−1597	$\frac{1}{2}$	−1619	$\frac{3}{4}$	....	....	−1685	$\frac{1}{4}$	....	....	....	....	....	....
4924·115	1597	$\frac{1}{2}$	1575	$\frac{3}{4}$	....	....	1670	$\frac{1}{2}$	....	....	....	....	....	....
4861·527	....	....	1615	$\frac{1}{4}$	....	....	1754	$\frac{1}{4}$	....	....	....	....	....	....
4584·018	1614	$\frac{1}{4}$	1617	$\frac{1}{4}$	....	....	1697	$\frac{1}{4}$	−1707	$\frac{1}{4}$	−1741	$\frac{1}{4}$	....	....
4549·766	1577	$\frac{1}{4}$	1645	$\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
4481·400	1583	$\frac{1}{4}$	1597	$\frac{1}{2}$	−1719	$\frac{1}{4}$	....	....	....	....	....	....	....	....
4468·663	1584	$\frac{1}{4}$	1582	$\frac{1}{2}$	1638	$\frac{1}{2}$	....	....	....	....	....	....	....	....
4443·976	1583	$\frac{1}{4}$	1586	$\frac{1}{4}$	1661	$\frac{1}{4}$	....	....	....	....	....	....	....	....
4340·634	1605	$\frac{1}{2}$	1579	$\frac{3}{4}$	1700	$\frac{1}{2}$	1703	$\frac{1}{4}$	1766	$\frac{1}{2}$	1735	1	−1763	1
4300·211	....	....	1493	$\frac{1}{4}$	....	....	....	....	....	....	....	....	....	....
4294·301	....	....	1638	$\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
4289·915	....	....	1579	$\frac{1}{2}$	....	....	....	....	....	....	....	....	....	....
4233·328	1595	$\frac{1}{2}$	1604	$\frac{1}{2}$	1645	$\frac{1}{4}$	1671	$\frac{1}{4}$	....	....	....	....	1718	$\frac{1}{2}$
4163·80−	1597	$\frac{1}{4}$	1575	$\frac{1}{4}$	....	....	....	....	....	....	....	....	....	....
4101·890	1595	$\frac{1}{2}$	−1604	$\frac{1}{2}$	1669	$\frac{1}{2}$	1675	$\frac{1}{2}$	1746	$\frac{3}{4}$	1743	1	1760	1
3970·177	−1623	$\frac{1}{4}$	....	....	−1705	$\frac{1}{2}$	−1704	$\frac{1}{4}$	1755	$\frac{1}{2}$	....	....	1776	$\frac{1}{2}$
3933·825	....	....	....	....	....	....	....	....	−1722	$\frac{1}{2}$	−1715	$\frac{1}{2}$	−1723	$\frac{1}{2}$
Weighted mean	−1597·00		−1596·87		−1671·27		−1690·40		−1733·10		−1735·02		−1751·86	
V_a	+ 9·22		+ 9·22		+ 8·80		+ 8·38		+ 7·96		+ 7·30		+ 6·64	
V_d	+ 0·03		0·00		+ 0·10		+ 0·10		+ 0·16		− 0·12		+ 0·03	
Curv.	− 0·43		− 0·43		− 0·43		− 0·43		− 0·28		− 0·28		− 0·28	
Radial Velocity	−1588·2		−1588·1		−1662·8		−1682·4		−1725·4		−1728·3		−1745·6	

MEASURES OF NOVA AQUILÆ NO. 3—*Continued*

λ	8589		8590		8596		8603		8605		8607		8609	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861·527	....	....	....	....	−1786	¼	....	....	....	....	....	....	....	....
4340·634	−1727	½	−1734	½	1762	¾	−1678·9	1	−1662·5	1	−1673·4	1	−1663·2	1
4101·890	−1763	½	1741	¾	1764	1	1667·6	1	1675·1	1	1676·5	1¼	1670·3	1½
3970·177	....	....	−1775	¼	−1756	¾	−1669·0	1	−1663·7	1	−1688·2	¾	−1663·7	1
Weighted mean	−1745·00		−1744·40		−1763·27		−1671·83		−1667·10		−1678·39		−1666·09	
V_a	+ 6·00		+ 6·00		+ 3·95		+ 0·81		+ 0·37		− 0·08		− 0·53	
V_d	+ 0·23		+ 0·19		0·00		+ 0·11		+ 0·09		+ 0·16		+ 0·02	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−1739·2		−1738·6		−1759·6		−1671·2		−1666·9		−1678·6		−1666·9	

λ	8612		8618		8619		8620		8621		8623		8624	
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4340·634	....	....	−1680·9	½	−1689·4	¾	−1677·7	¾	−1684·2	¾	....	....	....	....
4101·890	−1678·8	1	−1684·3	1	−1688·0	1	−1684·4	1	−1693·1	¾	−1681·4	½	−1698·4	½
Weighted mean	−1678·80		−1683·17		−1688·60		−1681·30		−1688·65		−1681·40		−1698·40	
V_a	− 2·39		− 4·15		− 4·61		− 5·06		− 5·96		− 6·38		− 6·38	
V_d	− 0·02		− 0·09		+ 0·07		+ 0·06		+ 0·09		+ 0·14		+ 0·04	
Curv.	− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28		− 0·28	
Radial Velocity	−1681·6		−1687·7		−1693·4		−1686·6		−1694·8		−1687·9		−1705·0	

λ	8559 b		8561 a		8572 b		8568 a							
	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.	Vel.	Wt.
4861·527	−2420	½	−2459	¾	−2462	½	−2281	¾	....	....	....	....	....	....
4340·634	2448	¼	2450	½	2329	½	2280	¾	....	....	....	....	....	....
4101·890	2229	½	−2230	¾	2335	¼	2295	¾	....	....	....	....	....	....
3970·177	−2234	½	....	....	−2342	¼	−2307	½	....	....	....	....	....	....
Weighted mean	−2316·30		−2369·30		−2376·53		−2289·25		....		....		....	
V_a	+ 9·22		+ 9·22		+ 8·80		+ 8·38		....		....		....	
V_d	+ 0·03		0·00		+ 0·10		+ 0·10		....		....		....	
Curv.	− 0·43		− 0·43		− 0·43		− 0·43		....		....		....	
Radial Velocity	−2307·5		−2360·5		−2368·0		−2281·2		....		....		....	

DETAILED DISCUSSION OF THE SPECTRUM OF NOVA AQUILÆ NO. 3

In addition to the main features of the spectrum, already discussed in the preliminary general statement, there were many less conspicuous but important details shown in the plates, and striking changes took place throughout the spectrum from time to time. These details and changes are dealt with in the following description of the spectrum as secured here from day to day.

June 9th.—The plates showed a fairly strong continuous spectrum with absorption bands about 8 angstroms wide, which were none too well contrasted. Besides the hydrogen series there were the *H* and *K* lines of calcium, the presence of the former line being fairly certain from the complex character of the line as combined with H_ϵ. Then there were other bands, in general much fainter than the hydrogen, having the following wave-lengths, λλ 5018, 4924, 4584, 4549, 4481, 4300, 4233 and 4163. All these bands were displaced from their normal positions to the violet by an amount corresponding to a velocity of approach of 1250 km. per second. As previously stated, this does not imply a translation of the star or of its vapours at this rate, but is only a ready method of expressing the displacement of the lines from their normal positions. The agreement among the different lines was all and even better than what could be hoped for, and revealed that in this nova, as in previous ones, the displacement of the lines was proportional to the wave-length. Besides the broad calcium bands there were also sharp *H* and *K* lines very slightly displaced from their normal positions towards the violet. While the broad bands shifted their positions from time to time, these latter well-defined lines have maintained a constant position which, as may be seen from an accompanying table, is of the order of 20 km. per second approach; that is, a displacement of about one-third angstrom to the violet of their normal positions. Nothing definite in the nature of emission can be seen on the plates taken throughout the night.

June 10th.—The first plate taken on this evening showed a decided change in the spectrum. Emission bands, particularly of hydrogen had now made their appearance, flanked on the side of greater refrangibility by pairs of absorption lines. The continuous spectrum is quite strong, yet there would seem to be no uncertainty in regard to the presence of the emission bands, even though they are not pronounced as yet. It is quite a task in a spectrum where both emission and absorption bands are present, as in this case, to properly interpret what one sees on the plate, and different persons might read quite different results from the same plate. In some cases weight may be given to the interpretation of the absorption lines as being simply spaces between the emission bands, but it seems to me in the case of Nova Aquilæ No. 3, on this date we have genuine absorption taking place. The appearance on this date is that of a strong continuous spectrum crossed by a great many absorption bands, and in addition having broad emission bands of hydrogen and possibly a few other substances. These absorption bands have been identified as due to hydrogen, magnesium, calcium and enhanced lines of iron, titanium and other substances, as indicated in one of the accompanying tables. Pairs of absorption lines, as mentioned just now, occur at the violet edges of the hydrogen emission, and also for wave-lengths, λλ 5018, 4924, and 4481, the least refrangible of the pair—the one corresponding to that of the previous evening—being always the more intense of the two. Measurements upon the most suitable 30 or 40 out of the total 70 odd, that can be counted between λ 3889 and λ 5018, show a displacement from their normal positions equivalent to a velocity of approach of 1426 km. per second. The corresponding displacement for the other members of the pair, about 8 or 9 in number, is for this night 2206 km. per second, as shown in the summary of measures.

June 13th.—The emission bands have become strengthened relative to the continuous spectrum. The numerous absorption lines seen on the 10th are missing; only those visible on the 9th remaining. All lines have shifted more to the violet, the displacements being represented by velocities of −1588 and −2360 km. respectively. The emission bands are not uniformly intense throughout their breadth, but appear as if annulled in several places by absorption lines. The more refrangible of the lines at λ 5018 and λ 4924 and apparently λ 4481 also are missing, while the corresponding one for H_β has become broadened and much intensified, with a corresponding decrease in intensity in the other member of the pair. The other hydrogen lines show a tendency to shift the intensity from the red to the violet member of the pair, though the effect is not so marked as in H_β.

June 14th.—The phenomena of the previous evening of the emission being "eaten out" in places by absorption is accentuated on plates of this date. There results the appearance of three distinct divisions to each of the hydrogen bands, the main one being some 10 or 15 angstroms wide at about the normal position of the line, the others less than half as broad, and centred roughly some 1200 or 1300 km., respectively, to the red and violet of the normal positions. Numerous other emission bands are without doubt present, there being a pair around λ 4625 and λ 4640, while from λ 4584 to λ 4501 there are several emission bands. Fewer definite absorption lines are seen than on the previous evening, and their displacements correspond to a negative velocity of 1663 km., while the second member of the hydrogen pair is about 2368 negative.

June 15th.—The emission and continuous spectrum is quite similar to that of the preceding evening, while the absorption lines have become fewer in number, being confined principally to the pairs of hydrogen lines; the enhanced lines, λλ 5018, 4924, 4584, 4233 and the calcium *K*.

June 17th.—There is considerable of a change on this date. The emission bands of hydrogen are much more uniform in intensity throughout their width. The change seems to have been gradual, as those of the 15th are slightly more uniform than those of the 14th. H_β extends from λ 4833 to λ 4889; H_γ from λ 4317 to λ 4364; H_δ from λ 4079 to λ 4122; H_ϵ from λ 3948 to λ 3990, so that the centres of the emission bands are in the normal positions of the lines and their width varies approximately with the wave-length. The emission is sharply terminated at the violet edge by the absorption line. The main difference to the preceding plates is the absence of the more refrangible of the pair of absorption lines which terminated the hydrogen emission bands on the violet, and which first appeared on the night of the 10th. Further, a new absorption band is beginning to show itself about λ 4060, with a tendency to have centres of intensity at λ 4056·7 and λ 4065·7. If these have suffered displacement like the other absorption lines, their normal values would be about λ 4081 and λ 4090.

June 18th.—Quite similar to the 17th. When the characteristic pairs of absorption lines occurred on the 10th there was slight absorption to the violet of the pair at λ 5018, which was not present on the preceding night. This has been steadily increasing in intensity and, being some 50 angstroms wide, is quite a noticeable feature of the spectrum at this phase. Its centre is at λ 4959·5 the position of N_2.

June 19th.—A pair of absorption lines to the violet of the 4640 band with centres at λ 4607 and λ 4595 are more definite, otherwise little change from the preceding night.

June 20th.—A further strengthening of intensity in the pair of absorption lines λ 4607 and λ 4595 and a decrease of the continuous spectrum relative to the emission are shown. The emission band at λ 4640, which could be detected as a strengthening of the continuous spectrum on the 13th, has gradually become stronger until now it is quite marked.

June 23rd.—The broad emission bands of hydrogen with an absorption line to the violet of each and with the additional very broad but not so intense emission at λ 4640 without absorption to the violet is what we find in spectra of this date. The continuous spectrum is weak. H_β has an absorption at the red edge of its emission. The appearance is as if emission was centrally superposed on a somewhat broader absorption. Instead of λ 4057 and λ 4066 which appeared on the 17th, though suspected on the 15th, there are two quite strong bands at λ 4059·4 and λ 4054·3, the former and λ 4057 perhaps being one and the same band.

June 25th.—Somewhat similar to the 23rd, though the continuous spectrum is more intense and the λ 4640 emission relatively much fainter than on that date. Rough estimates of the relative intensities of the continuous spectrum to H_δ, H_γ and H_β are as 1 to 5 to 10 to 25. Quite definite centres of intensity appear at λ 4055 and λ 4060.

June 26th.—The continuous spectrum is weak and the absorption lines which terminated the violet edges of emissions are now lost. The emission bands at λ 4640 and those due to hydrogen have the appearance of being double, owing to their centres being "eaten out" by absorption whose width is about one-half their own. Additional emission bands 5 or 10 angstroms wide are seen at λλ 4584, 4530, 4490, 4450, 4434, 4395, 4302 and 4252. Absorption extends from λ 4062 to λ 4075 without any particular centre of intensity.

June 28th.—The plate is too weak for definite study, but the emission bands appear to be the same as on the 26th. The centres of intensity for the λ 4640 emission are at λ 4618 and λ 4658.

June 29th.—Again the appearance of centrally superposed absorption bands on broader emission. Faint emission extends approximately from λ 5030 to λ 4980 with absorption cutting out the centre, leaving strips of emission about 8 or 10 angstroms wide whose centres are at λ 5024 and λ 4984. Strong H_β emission extends from λ 4888 to λ 4834, eaten out by centrally placed absorption about half the width of emission. The red portion of the emission is the more intense. Faint emission extends from λ 4710 to λ 4666, then emission as strong as H_β from there to λ 4614, whose central portion suffers partial absorption, leaving strong centres of emission at λ 4658 and λ 4622. Similar emission strips are seen in the region λ 4584 to λ 4382, as on the 26th. H_γ emission extends from λ 4364 to λ 4316, with central absorption, the red portion of the remaining emission centred at λ 4359 being more intense than the corresponding violet portion, just as was the case with H_β. H_δ extends from λ 4124 to λ 4075, with absorption and other features similar to H_β and H_γ. H_ϵ is much fainter, but seems similar to others. In general, the emission bands are 50 angstroms wide and decrease in intensity with decreasing wave-length.

July 2nd.—The continuous spectrum has again become strong and with its increased intensity the absorption line, which formerly terminated the violet edges of the hydrogen emissions, again reappears, this time as a close double in H_γ, H_δ and H_ϵ. The emission band at λ 4640 has its intensity relative to the hydrogen bands diminished to a considerable degree, the appearance being more of a strengthening of the continuous spectrum in that region. Rather indefinite centres of intensity are seen at λ 4053 and λ 4060 for that particular absorption band. The star has, of course, brightened up since the last observation.

July 3rd.—The absorption pair terminating H_γ, H_δ and H_ϵ is more pronounced than on the preceding evening. Expressed in velocities they are − 1667 km., and − 1802 km.

July 4th.—In general similar to preceding.

July 5th, 6th.—The more refrangible of the pair of absorption lines seen on the 2nd, 3rd and 4th is now missing. The λ 4060 band has a tendency to show centres of intensity at λ 4057 and λ 4062.

July 9th.—Emission becoming the predominant feature, that at λ 5007 regaining in intensity relatively to the others. The only absorption line seen bordering the hydrogen emissions is that at H_δ. Absorption occurs at λλ 4573, 4555, 4500, 4445, and a narrow pair at 4422, 4421, and faint absorption at λ 4109. There is also a pronounced absorption line near λ 4096. Its position is identical with those measured as hydrogen lines from July 19th to November 10th. This seems to be a transition date.

July 10th, 11th, 12th.—Emission similar to the 9th. H_δ and λ 4096 absorption absent. The spectra of these dates is somewhat similar to that of June 29th, when the star was about the same magnitude. In the interval, it increased in brightness probably 0·7 magnitude and has diminished again by the same amount. There are some differences, and a fuller description is in order. There are six prominent emission bands, H_β, H_γ, H_δ and λ 4640, and of lesser intensity λ 5007 and H_ϵ. These have the appearance of being superposed on absorption bands greater in width by 20 to 40 angstroms. Emission extends from λ 4671 to λ 4606, and shows a tendency to resolve into two parts. More-over, while it fades off gradually into the continuous spectrum at its violet edge it would apparently continue some 40 angstroms further to the red were it not for absorption which cuts into it, leaving two disjointed strips of emission. Similar faint emissions are seen at λλ 4584, 4549, 4529, 4491 and a strip from λ 4466 to λ 4445 terminated by an absorption band or series of absorption lines. The extreme limits of H_γ and the nebular λ 4363 emissions are from λ 4316 to λ 4385 and are fairly well defined. The strong portion is from λ 4335 to λ 4363, but this itself is eaten into centrally by absorption lines. H_δ and H_ϵ have the usual limits. Thus the emission bands of hydrogen, their widths 40 to 50 angstroms and roughly proportional to their wave-lengths, continue to be near the normal positions of the lines.

July 13th, 14th, 15th.—Differs from preceding in that sharp H_γ and H_δ absorption lines are seen to the violet of the emissions.

July 17th.—Continuous spectrum stronger. A decided pair of absorption lines at λ 4051·3 and λ 4057·9. Broad absorption lines have appeared gradually of late at λ 4572 and λ 4554. The star for the last few evenings has been 2 or 3 tenths of a magnitude brighter than it was one week ago.

July 18th.—The line λ 4051 of the preceding night is faint, while λ 4058 is missing entirely. If H_γ absorption is present it is very faint and diffuse.

July 19th.—Continuous spectrum decidedly weaker. There are indications of the λ 4051 and λ 4058, but none of the λ 4554 and λ 4572, though the continuous spectrum is of sufficient intensity to reveal them. The absorption lines to the violet of the hydrogen emissions are missing entirely.

July 20th.—There is stronger absorption from λ 4575 to λ 4549 and emission at λ 4584 and λ 4528, which does not show on the plate of the preceding night.

July 21st.—Continuous spectrum weakened and emission less uniform as absorption has eaten into their centres. The spectrum of this date is a replica of June 26th, with the addition of the nebular emission λ 4363, which joins on to H_γ, and extends to λ 4385.

July 24th, 25th, 26th.—The main emission at H_β is some 50 angstroms wide "eaten out" centrally by absorption. Emission reversal 10 angstroms wide is centred at the normal position of the line. All emission is more uniform, otherwise general features as on the 21st.

July 30th and 31st.—The nebular emissions at λ 5007, λ 4363, are about equally bright with H_γ and only slightly less so than H_β. Emission is even more uniform than immediately preceding dates.

August 1st.—Identical with spectrum of July 21st. Approaching minimum in both cases.

August 23rd, 24th, 25th, 26th, 27th, 29th;
September 7th, 21st, 22nd, 30th;
October 3rd, 8th, 21st;
November 2nd, 10th.—The plates of these dates are quite similar in general, and consist principally of emission bands as given in the following table. Since about the 21st of July the continuous spectrum has pretty well vanished and what changes have taken place are details within the emission. The nebular emissions, N_1 (λ 5007) and N_2 (λ 4959) have on the whole strengthened during the interval. The tendency has been for the absorption within the emissions to show itself more as definite lines.

SUMMARY—EMISSION SPECTRUM—JULY 19 TO NOVEMBER 10

	Red Edge	Violet Edge	Centre
Faint emission	5033·7	5014·0	
Strong emission N_1	5014·0	5000·4	5007·2
Faint emission	5000·4	4977·7	
Faint emission N_2	4966·0	4952·5	4959·2
$H\beta$ emission	4887·6	4833·4	4860·5 ± 0·03
Faint emission	4710·9	4679·	
Strong emission	4668·8	4612·4	4640·6
Faint emission } λ 4363	4387·2	4368·	
Strong emission } and	4363·3	4336·7	
Faint emission } $H\gamma$	4336·7	4315·8	
$H\delta$ emission	4123·2	4075·5	4099·8

The foregoing limits were computed from measures made upon the plates, using the Hartmann interpolation formula. Naturally more or less error exists in the measures, as some of the edges are not well defined. H_δ while fairly definite at the red edge, is not so at the violet and towards the close of the interval stated the entire emission there becomes quite weak. $H\gamma$ cannot be dissociated from the nebular 4363 emission. At times an increased intensity is shown at λ 4370 to λ 4358 as if due to overlapping. A similar case exists with the 4640 band, though on July 21st and August 1st the two emissions are definitely separated with centres at λ 4612 and λ 4659. The N_1, N_2 and H_β emissions are fairly well defined, however. With H_β the greatest range in the measures for either limit is 1·8 angstroms with a probable error for the mean of 24 plates of less than 0·1 angstrom, and it would seem that the displacement to the violet of 1 angstrom cannot wholly be accounted for by error of measurement. It should be stated that its centre for the period, June 17 to July 17 inclusive, was 0·4 angstroms to the violet but the limits were not nearly so definitely determined. Correction of course has been made for the 20 km. velocity of approach. H_δ is in the same direction 2 angstroms, but its centre likewise cannot be so definitely established.

Besides the absorption lines, hereafter spoken of as the hydrogen lines from the fact that their displacements from their normal positions are proportional to their wavelengths, the following are measured on the majority of the plates in this interval. A band 12 angstroms wide centred at λ 4971·8 is also a feature which intensifies as time proceeds.

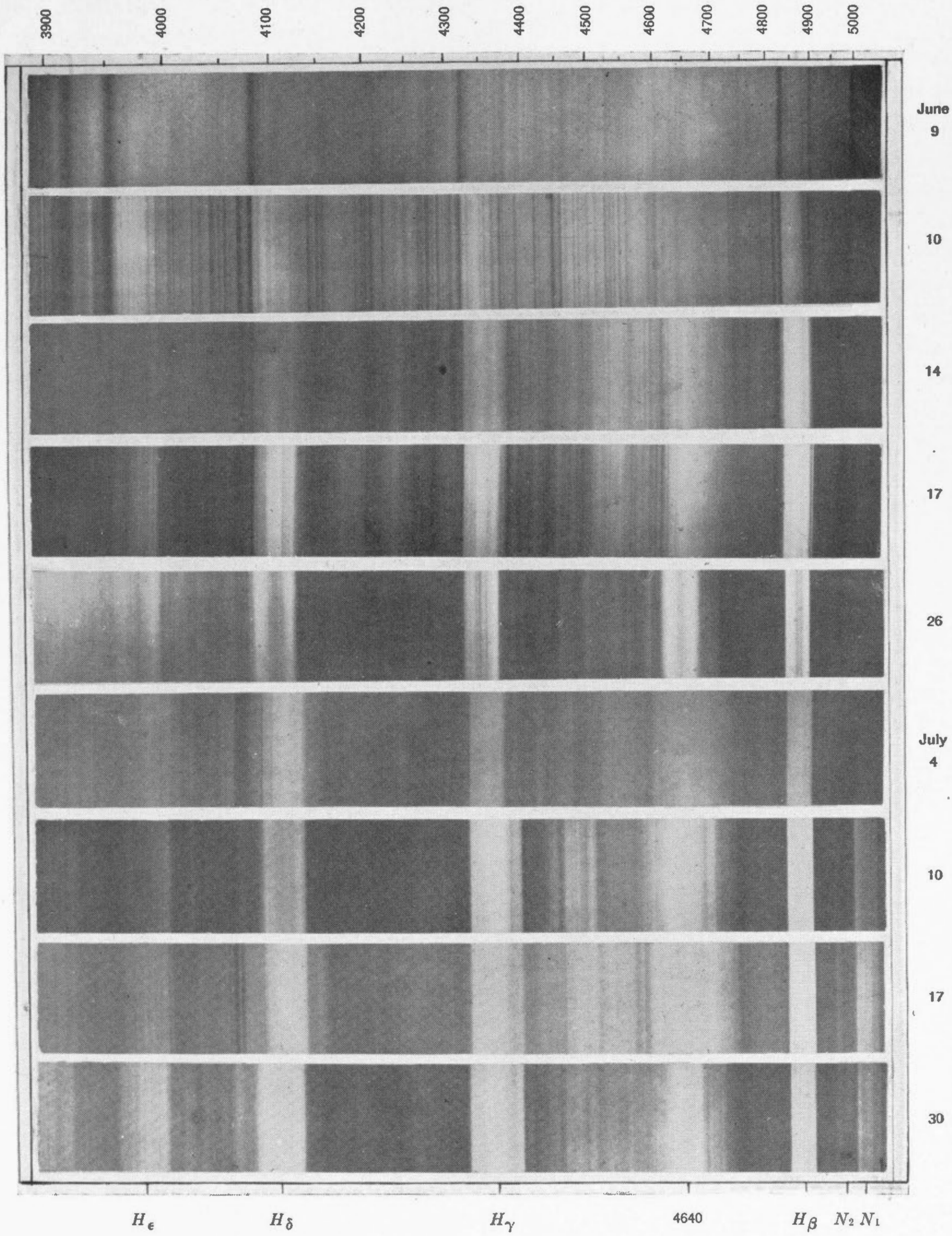
ABSORPTION LINES

5017·0	4383·4	4127·2
4951·6	4372·0	4125·1
4633·5	4357·2	4120·0
4612·3	4337·5	4115·8

Absorption lines were always present some 6 or 7 angstroms to the violet of H_β, H_γ and H_δ during the interval quoted, and became increasingly better defined as time proceeded. On the assumption that they are due to hydrogen, their displacements—using the velocity idea—are as given in the following table. The agreement among themselves was all that could be desired.

DISPLACEMENTS HYDROGEN ABSORPTION LINES

Date	Velocity	Weight	Date	Velocity	Weight
1918			1918		
July 19	−455	¾	Aug. 26	−443	1¾
" 20	453	¾	" 27	444	1½
" 21	448	¾	" 29	451	1½
" 24	450	½	Sept. 7	442	1½
" 25	456	1	" 21	462	½
" 26	443	1	" 22	447	1½
" 30	439	1¼	" 30	446	1
" 31	445	¾	Oct. 3	440	1
Aug. 1	442	1	" 8	449	1¼
" 23	443	2¼	" 21	447	1
" 24	434	1¼	Nov. 2	444	¾
" 25	−449	1¼	" 10	−444	1½



Spectrum of Nova Aquilæ No. 3

66701

Enlarged 3·9 times in length and 37 times in width

The mean is $-446 \cdot 0$ corresponding to a displacement at H_γ of $6 \cdot 5$ angstroms with corresponding values for H_β and H_δ.

The spectra shown are from the original negatives enlarged lengthwise three and nine tenths times and thirty-seven fold in width. They show the most characteristic types. The first two illustrate the rapid change that took place in the 16 hours or so between observations late on the 9th and early on the 10th, and makes one sceptical of a stellar classification in which we are led to think of millions of years being required for a star to pass from one type to another.

To discuss fully the probable causes of the origin of new stars and the various theories that have been put forward from time to time to explain them would be out of place in an article already lengthy. It may be permitted to make some comparisons, however, between this nova and other striking ones, particularly Nova Aurigæ (1892), Nova Persei (1901) and Nova Geminorum (1912) and to point out wherein some of the theories fail to satisfy the observed facts.

(1) The region of the sky in which it occurred is noteworthy. Apart from the numerous faint novæ found recently in spiral nebulæ they are all situated in the plane of the Milky Way, where matter is more plentiful and where collisions would be more likely to occur than elsewhere.

(2) This was a known star and it required at least three days to increase to its maximum light. This would discredit the theory, adopted many years ago to account for new stars, of a collision occurring between two practically dead worlds, for according to that theory a few hours would suffice for the bodies to cut through each other with the tremendous velocities they were assumed to possess. The Director, Dr. Otto Klotz, has made the suggestion that since this was a known star if a change in proper motion can be shown to have taken place in the star after the outburst, then some weight would be lent to the collision theory. It is doubtful, however, if the previous observations were of sufficient precision to definitely settle the matter.

(3) If we accept the measures of the sharp H and K lines of calcium, which are presumably reversals, as representing the radial motion of the star then the three novæ,—Persei, Geminorum and this one—in which these lines have been well measurable, have radial velocities which are approximately zero with reference to the stellar system.

(4) The strong continuous spectrum before maximum light was reached, while possibly accounted for by high pressures, would more reasonably suggest that some internal cause was heating up the core of the star. On the other hand, the rapid diminution in light after it had reached its maximum would argue for superficial disturbances as would also the fact that the continuous spectrum rapidly faded and was replaced by one of a nebular type, noticeable after a week and quite strong in a month's time.

(5) The history of the star, since it was first photographed 30 years ago, shows it to have been varying in light over two magnitudes, and this might incline us to the idea that the causes operating in variable stars were present here also. Then the similarity of the oscillations, which took place in the light of the star during July and August, to those occurring in Cepheid variables in which the time from minimum to maximum is shorter than from maximum to minimum should be noted, though the point should not be strained too far. It may be added, that all the better observed novæ show these oscillations in brightness.

(6) The greater the outburst, the greater the widths of the emission lines and the greater the displacements of the absorption lines. Tabulating the four novæ in order of maximum brightness we have:

Nova	Mag.	Width Em.	Dispt. Absorption
Aurigæ	4·7	15 A	−700 km. per sec.
Geminorum	4·0	24 "	−850 " "
Persei	0·5	33 "	−1100 to −1500 " "
Aquilæ	−1·5	47 "	−1250 to −1750 " "

The collision theory was adopted in the case of Nova Aurigæ by several, among whom was Vogel, who afterwards discarded it in favour of the idea, that alternate layers in the star's atmosphere gave rise to bright and dark bands and that owing to pressure the emission bands were slightly displaced to the red from their normal positions, thereby leaving uncovered at their violet edges portions of the absorption bands. This conclusion was based upon Wilsing's work on the pressure effects on gases, and more particularly upon the earlier and more comprehensive work of Jewell, Humphreys and Mohler. This explanation will not suffice in the present instance, for in addition to the hydrogen lines, which appear as both emission and absorption, we have numerous metallic lines which appear as absorption only, and yet suffer displacements similar to those of hydrogen.

Seeliger's theory of a main body approaching the sun and running into a cosmic cloud, and Lockyer's idea of the meeting of not one but two cosmic streams, one denser than the other, both have some resemblance to the popularly accepted theory of a body approaching the inert stage and in its motion through space becoming enmeshed in a nebula.

The explosive theory was put forward by W. H. Pickering, and in view of our recent knowledge regarding the pent up energy in radio-active substances is not without merit, particularly if we assume, as did Huggins, that the close approach of the two bodies caused them to become more and more distorted and elongated until finally the great outburst occurred. Pickering's latest idea is that of a meteor plunging into a so-called dead world.

The earlier novæ all showed displacements of the emission bands towards the red, which in the case of Aurigæ amounted to about 6 angstroms, and these bright bands were assumed to belong to the receding star. When other novæ likewise showed redward displacements the case was weakened, for why should not novæ be found in which the bright-line star was approaching and not receding? The displacements of the emissions were in the same direction in Geminorum and Persei, but they were much smaller in amount, and in Nova Aquilæ the displacement was if anything to the violet.

When our knowledge of the laboratory behaviour of gases under varying conditions of pressure and temperature—not overlooking anomalous dispersion phenomena—is more complete, we will be in a better position to theorize regarding the origin of new stars. A hopeful sign lies in the fact, that spectra of some nebulæ show remarkable resemblance to those of novæ. Slipher secured a spectrogram of Hubble's variable nebula requiring 37 hours exposure, which shows numerous bands and lines that were present in certain stages of former novæ. In the meantime, we are glad that the present nova has given opportunity to learn a few additional facts regarding these interesting objects.

Dominion Observatory
Ottawa
December, 1918.

Note added while going through the press.

A spectrogram taken, 1919, March 13·92, shows the nebular emissions λλ 5007·2. 4959·2 and 4362± in this order of intensity; the two former having well-defined limits and being about 12 angstroms wide, while λ 4362 was about 50 angstroms wide with ill-defined limits.