LICK OBSERVATORY

UNIVERSITY OF CALIFORNIA

BULLETIN No. 8

MERIDIAN CIRCLE POSITION OF NOVA PERSEI

The position of Nova Persei has been determined on eight consecutive nights, from February 24 to March 3, 1901.

With the mean result, below, are given the adopted places of the Fundamental Stars employed, taken from AUWERS' corrections to the A. G. Catalogue, and referred to the mean equinox 1901.0. The corrections necessary to reduce the place of Nova, to correspond with NEWCOMB'S Fundamental Catalogue, are: $+0^s.021$ and $+0'.30$. Both circles were read for the observations of the last four nights, for stars and nadir; and the East circle was shifted to a new position, each night. The corresponding values of the Declination of Nova from the two circles, on these four nights, are given separately.

The magnitude was estimated at 1.0, at 8 P. M. February 24, the day the announcement of discovery reached us. The brightness has declined to $2\frac{1}{2}$ since that date, but the decline has been subject to fluctuations, from night to night. The color has been distinctly red.

	R. A.	1901.0	Decl.	No. Obs.
α Persei	3 ^h 17 ^m 15 ^s .054		49° 30' 32".13	7
Nova	3 24 28.086		43 33 54.03	8
"			W 54.01	4
"			E 54.05	4
δ Persei	3 35 52.378		47 28 15.80	8
ϵ Persei	3 51 12.472		39 43 26.21	7

R. H. TUCKER.

March 4, 1901.

[NOTE.—The telegram announcing ANDERSON'S discovery of the new star in Perseus on the morning of February 22d, promptly sent out by Harvard College Observatory, was not received at the Lick Observatory until the morning of February 24th. A severe storm on the preceding days had temporarily interrupted our telephone communication with San José. No opportunities were lost on this account, as the nights of February 21, 22 and 23 were cloudy.

The Nova was looked for with the 12-inch refractor on the forenoon of February 24th, and found without difficulty. It was considerably brighter than Capella. Making reasonable allowance for the fact that Capella was observed at a lower altitude than the Nova, the latter was estimated to be half a magnitude the brighter.—W. W. C.]

RELATIVE POSITIONS OF NOVA PERSEI AND THE STARS NEAR IT

The following measures were made for the purpose of determining the position of the new star with reference to the faint surrounding stars. All the stars that could be seen with the 36-inch telescope, in February and March, within 3' of the Nova, were measured, as well as a few that are more distant. As all of these stars are quite faint, the Nova was also connected with the 9.0 magnitude star (Boin A. G. Catalogue 2948), which is about 6' north of and preceding it.

The observing conditions on the nights available

for these measures were not very favorable, and the measures of distance were nearly all difficult. This was especially the case with the nearest star (α), which was at the limit of vision. The estimates of magnitude must be considered as relative rather than absolute. In addition to the estimates on the nights of the measures, the following comparative estimate was made on March 29th: $o=12.5$; $k=i=f=13.0$; $l=m=13\frac{1}{4}$; $j=c=13.5$; $g=h=n=14.0$; $b=14\frac{3}{4}$; $e=15.5$; $d=16.0$; a , not visible.

The accompanying diagram shows the positions of these stars.

In July, after the new star had become a morning object, a number of the measures were repeated. The atmospheric conditions were good, though the observations were made at rather large hour angles,—five hours at the beginning of the measures. The magnitude of the Nova on these nights was estimated at 6.6 to 6.7. A number of faint stars were seen in this region which were invisible in February and March, probably on account of the stronger illumination of the field at that period by the bright Nova.

Nova and <i>a</i> .			
Date.	Angle.	Distance.	Magnitude.
1901.184	348°0	39".39	— 16.5
.203	348.7	40.28	— 16.5
1901.19	348.4	39.82	— 16.5

Nova and <i>b</i> .			
1901.184	107°9	90".86	— 14.5
.239	108.1	91.88	— 14.5
1901.21	108.0	91.37	— 14.5

Nova and <i>c</i> .			
1901.159	117°2	102".31	— 13.5
.184	116.6	102.30	— 13.5
.239	116.7	103.33	— 13.5
1901.19	116.8	102.65	— 13.5

Nova and <i>c</i> .			
1901.570	116°6	102".97	

Nova and <i>e</i> .			
1901.203	142°7	121".34	— 15.5

Nova and <i>f</i> .			
Date.	Angle.	Distance.	Magnitude.
1901.159	211°4	123".96	— 13.0
.184	210.9	125.13	— 13.0
.239	210.9	124.76	— 13.0
1901.19	211.1	124.62	— 13.0

Nova and <i>f</i> .		
1901.542	210°8	124".49
.570	210.7	124.50
1901.56	210.7	124.50

Nova and <i>i</i> .			
1901.159	62°8	158".33	— 13.0
.184	63.2	158.21	— 12.5
.203	63.3	157.95	— 13.5
1901.18	63.1	158.16	— 13.0

Nova and <i>i</i> .		
1901.542	63°3	159".07
.570	63.3	159.50
1901.56	63.3	159.28

Nova and <i>k</i> .			
1901.203	114°6	168".86	— 13.0
.239	114.5	170.64	— 13.5
1901.22	114.5	169.75	— 13.2

Nova and <i>k</i> .		
1901.542	114°5	171".32
.570	114.2	169.94
1901.56	114.4	170.63

Nova and <i>n</i> .			
1901.184	352°0	192".75	— 13.5
.239	352.3	193.39	— 14.0
1901.21	352.2	193.07	— 13.8

Nova and <i>n</i> .		
1901.542	352°8	192".90
.570	352.8	193.53
1901.56	352.7	193.21

Nova and <i>o</i> .			
1901.159	300°3	236".35	— 13.0
.184	300.4	236.63	— 12.0
1901.17	300.4	236.49	— 12.5

Nova and <i>o</i> .		
1901.542	300°7	235".99
.570	300.4	235.54
1901.56	300.6	235.76

Nova and <i>p</i> (= Bonn A. G. 2948).			
1901.176	321°6	367".73	— 9.0
.184	321.7	367.45	— 9.0
1901.18	321.6	367.59	— 9.0

<i>e</i> and <i>d</i> .			
1901.203	306°7	19".50	— 16.0

19011110B...1...40T

<i>i</i> and <i>g</i> .				<i>o</i> and <i>l</i> .			
1901.203	270°4	30°91	— 13.5	1901.159	144°2	61°39	— 13.5
.239	269.6	31.34	— 14.5	.184	144.2	61.68	— 13.0
1901.22	270.0	31.12	— 14.0	.239	144.3	61.99	— 13.0
				1901.19	144.2	61.69	— 13.2
<i>i</i> and <i>h</i> .				<i>k</i> and <i>m</i> .			
1901.203	194°5	45°42	— 13.5	1901.203	100°4	21°39	— 13.5
.239	195.4	45.97	— 14.0	.239	100.2	22.01	— 13.0
1901.22	195.0	45.70	— 13.8	1901.22	100.3	21.70	— 13.2
<i>o</i> and <i>j</i> .							
1901.159	114°9	71°71	— 13.0				
.184	114.7	72.78	— 14.0				
.239	114.5	71.85	— 13.5				
1901.19	114.7	72.11	— 13.5				

R. G. AITKEN.

MAGNITUDE ESTIMATES OF NOVA PERSEI

Estimates of the brightness of the new star in Perseus have been made as regularly as possible since February 24th.

These estimates at first were made without any instrumental aid by comparing the star with Capella, α , ϵ , δ , ν , χ Persei. As the star's light faded, opera glasses, and later the 3-inch finder of the 12-inch telescope, were used, comparisons being made with the stars ψ , σ , l Persei, and with BD + 43°674, BD + 45°778, BD + 44°734; the magnitudes of the comparison stars being taken from HAGEN'S Chart I.

The observations show that the light of the Nova, while it has been fading, has been subject to marked fluctuations almost from the beginning—a fact that is abundantly confirmed by observers elsewhere. But no definite period of variation can be satisfactorily established from the observations made here, nor yet by combining with them those made at other places, so far as these have been published.

The following table gives the magnitudes of the new star derived from my observations:

1901	P. S. T.	Mag.
Feb. 24	8 ^h	0.5
25	1	1.0
25	6:30	0.9
26	7:30	1.4
27	7	2.0
28	10	2.0
Mar. 1	8	2.4
2	7	2.4
3	7	2.5
4	8:20	2.5
5	7—10	2.7
6	7—10	3.0
8	7	3.2
12	9	3.5
13	9	3.7

1901	P. S. T.	Mag.
Mar. 14	7—10	3.5
15	8	3.8
16	8	3.9
17	8—10	3.9
18	8	4.0
19	7—9	4.1
20	7:30	4.5
22	8	4.7
23	7	4.0
28	8	4.7
28	10	5.0
29	9	5.0
31	9	4.7
Apr. 1	9:30	4.5
4	7:30	4.2
5	8	4.7
6	8	5.0
7	8	5.4
8	9	4.2
9	8	5.0
10	9	5.5
11	8—10	5.7
13	7:30	6.0
14	8	6.1
15	8	6.1—6.2
16	8	6.0—6.1
17	7:30	4.4
19	8	5.5
20	8	6.2
21	8	5.6
22	8:30	4.7
23	7:30—9:30	4.5
25	8	5.3
26	8:30—9	5.4
May 2	8:45	4.7
3	8:15	5.4
4	8:30	6.0
5	8	6.0
6	8	5.8
7	8	4.4
8	8	5.3

1901	P. S. T.	Mag.	1901	P. S. T.	Mag.
May 9	8	5.8	June 21	15:15	6.0
10	8	6.0	22	13:05	6.2
11	7:50	6.0	24	15	5.8
12	8:30	5.7	26	13	6.0—6.2
13	8:15	5.5	27	13:15	6.0—6.2
14	8:20	5.7	28	13:30	6.0—6.1
15	8:25	6.0	29	13	6.25
16	8	5.8	July 1	15	6.2—6.3
17	7:50	4.7—4.8	4	12	6.2—6.3
19	8	6.0—6.2	5	15:40	6.4
23	15:30	6.0—6.1	6	14	6.4
28	15:30	6.0—6.1	9	12	6.4—6.5
30	15:25	6.2	10	12:20	6.5
31	15	6.3—6.4	11	15:30	6.5—6.6
June 1	15	6.25	12	13	6.5
2	14:45	6.0—6.25	14	13:30	6.5—6.6
3	15	4.9—5.0	16	12	6.5
4	15	5.8—6.0	17	14:30	6.7
5	15:30	6.0	18	12	6.5
6	14	6.25	22	12:30	6.5
7	14	5.8	23	12	6.6
8	14	6.0—6.2	24	11	6.7
13	14	5.75	25	11:15	6.6—6.7
14	14	5.6—5.7	26	12	6.6
18	15	6.0	27	15	6.75
20	15:15	6.2			

R. G. AITKEN.

THE BRIGHTNESS OF NOVA PERSEI

The magnitude of Nova Persei seems to have remained practically constant during the last month. On thirty-two nights between July 26 and September 13 I estimated the magnitude, using mostly an opera glass, but sometimes a small telescope, or the finder of the twelve-inch refractor. While some variations have appeared in the estimates, it is probable that they are simply accidental, depending upon the stars employed in comparison. Simultaneous observations on one or two nights by Messrs. HUSSEY, AITKEN and WRIGHT show that my estimates make Nova a little brighter than they do. They all agree in the estimate of about 6.7 mag., while mine has been 6.3. Perhaps the discrepancy is due to differences in color-perception. The magnitudes of the comparison stars were taken from the H. P. column of HAGEN'S First and Second Charts for Observing Nova Persei.

While my estimates of absolute magnitude may have made it systematically too bright, yet I would have noticed any change. We may therefore conclude that the Nova has remained practically constant in brightness from July 22 to September 13, and assign to it

the magnitude 6.3 from my observations alone, and 6.6 from those secured by the four observers.

The data furnished by the observations are as follows:

1901	P. S. T.	Mag.	1901	P. S. T.	Mag.
July 26	12.0 ^h	6.5	Aug. 22	10.2 ^h	6.3
27	11.5	6.5	24	10.2	6.3
28	11.5	6.1	25	11.2	6.3
Aug. 1	11.4	6.1	26	11.8	6.3
2	10.9	6.1	27	11.2	6.3
3	12.5	6.0	28	13.0	6.3
6	12.1	6.0	29	12.0	6.3
7	12.0	6.0	30	12.0	6.3
8	13.3	6.1	Sept. 1	11.1	6.3
9	14.0	6.1	2	11.5	6.3
10	12.5	6.1	3	11.8	6.3
12	14.6	6.6	4	11.0	6.3
14	12.0	6.6	5	12.4	6.3
15	12.0	6.0	8	11.2	6.3
17	10.4	6.0	9	12.5	6.3
21	14.8	6.0	13	10.0	6.3

JOEL STEBBINS.

September 14, 1901.

Fig. 1.

Fig. 2.

Figure 1.—NOVA PERSEI, enlarged 7-fold. 1901 February 25.

Figure 2.—NOVA PERSEI, Intensity Curve. 1901 February 25.

Fig. 3.

Fig. 4.

Figure 3.—NOVA PERSEI, enlarged 7-fold. 1901 March 18.

Figure 4.—NOVA PERSEI, Intensity Curve. 1901 March 18.

Fig. 5.

Fig. 6.

Figure 5.—NOVA PERSEI, enlarged 7-fold. 1901 April 5.

Figure 6.—NOVA PERSEI, Intensity Curve. 1901 April 5.

Figure 7. NOVA PERSEI, D region, enlarged 8-fold. 1901 February 28.

Figure 8. NOVA PERSEI, D region, enlarged 8-fold. 1901 March 3.

Figure 9. NOVA PERSEI, H and K region, enlarged 9-fold. 1901 February 25.

Figure 10. NOVA PERSEI, enlarged 7-fold. 1901 July 15.

Figure 11. NOVA PERSEI, Intensity Curve. 1901 July 15.

Figure 12. N. G. C. 7027, enlarged 7-fold. 1901.

Figure 13. NOVA PERSEI, enlarged 8-fold. 1901 August 11.

Figure 14. NOVA PERSEI, Intensity Curve. 1901 August 11.

Figure 15. NOVA PERSEI, $H\gamma$ region, high dispersion. 1901 September 3.

OBSERVATIONS OF THE SPECTRUM OF NOVA PERSEI

At the time of the discovery of Nova Persei, the two single-prism spectrographs, with which all our low-dispersion photographs of the past ten years were secured, had just been shipped to Sumatra with the CROCKER Eclipse Expedition. This shipment, including likewise several minor pieces of apparatus, left the spectroscopic resources of the Observatory temporarily inadequate for the efficient analysis of the star's light. The MILLS Spectrograph was too powerful for a qualitative study of the spectrum, and was limited in its action to parts of the blue and violet regions. Fortunately, we possess an abundant supply of large 60° prisms, both light and dense; and from these, in connection with the MILLS Spectrograph, new and efficient apparatus was designed and constructed as required.

In all the spectrographs employed, and described below, the collimator section of the MILLS Spectrograph was used; and the changes made relate entirely to prism boxes, cameras, and braces for supporting the cameras. It will be a convenience in the discussion of the observations to have some ready method of referring to the different combinations of apparatus.

The MILLS Spectrograph, as ordinarily employed, will retain its usual designation.

The other instruments, referred to as spectrographs I, II, III and IV, will now be described.

I. A brass prism box, designed some years ago by Mr. CAMPBELL, for converting the MILLS Spectrograph into a one-prism instrument, was made ready for use by the evening of February 25th. It contained a single 60° light flint prism, and carried the regular MILLS camera of 406^{mm} focal length. The instrument was found to give excellent definition from above λ 3700 to λ 5700. By tilting the plate slightly, the definition was equally good from λ 4000 to λ 6000.

II. A large 60° dense flint prism, and a visually corrected triple lens of aperture 5^{cm} and focal length 53^{cm}, were mounted in wood, and attached to the collimator section of the MILLS Spectrograph. Most of the visual observations, and some photographs in the yellow and orange regions, were secured with this instrument. It replaced spectrograph I late in the evening of February 25th, and visual observations were obtained. The fine dark *D* sodium lines in the broad bright *D* band were seen at once, and with ease. The dark lines were compared directly with the bright *D* lines from an alcohol flame; and the star's lines were estimated by the two observers, respectively, to be displaced to the red about an eighth and a tenth of the distance between *D*₁ and *D*₂. These

estimates—corresponding to radial velocities of 38 and 30 kilometers per second—were in close agreement with the photographic results [see page 51] secured a few nights later.

III. It was considered very desirable to obtain high-dispersion photographs of the *D* region. As the MILLS Spectrograph is limited to portions of the blue and violet, it was necessary to construct another prism box, and some auxiliary apparatus, to secure the desired result. A prism box to hold three very dense 60° prisms was constructed of wood by the Observatory carpenter, from designs by Mr. WRIGHT. The whole matter of designing, constructing, adjusting and testing the apparatus required a day and a half. The instrument gave excellent results; no effects of flexure or shrinkage of the wood during the long exposures were visible. With the 406^{mm} camera, the separation of the *D* lines is 0.15^{mm}.

IV. Another box, similar in design to the one described in the preceding paragraph, was constructed for the purpose of photographing the *H* and *K* regions under high dispersion. It was lighter in some of its parts, and gave evidence of flexure. Results of value were secured with it, however. The three MILLS prisms were used in this box, as the denser ones were entirely too yellow for work in the violet.

The comparison lines used include those of iron, magnesium, sodium, hydrogen and helium. Wavelength determinations have in all cases been based on the HARTMANN-CORNU formula.

The spectrum was recorded from *H* δ to *H* β on February 24th, with the MILLS Spectrograph. The *H* δ , *H* γ and *H* β bands of hydrogen were bright, and extremely broad, and were accompanied on their violet sides by very broad absorption bands. Otherwise the spectrum appeared to be strictly continuous. The absorption in the dark bands was only partial, so that the contrasts between bright and dark bands were very slight. The *H* β bands were easily visible, but the *H* γ and *H* δ bands were rather difficult, as a result of the too strong dispersion afforded by this instrument. The general character of the spectrum would have been shown much better by one-prism spectrograms.

On February 25th, photographs were secured with spectrograph I, and the star was observed visually with spectrograph II. Numerous bright and dark lines were easily observed; and while allowance must be made for the lower dispersion used, it is safe to say that in the region of the spectrum photographed on the preceding night, the bright bands, and the con-

trasts between bright and dark bands, were relatively much stronger. The bands appeared to be identical with those in the early spectrum of Nova Aurigæ (February, 1892), but in the earlier star the bands were much narrower, and the contrasts were vastly stronger.

H_α was very bright, and situated with reference to the artificial H_α line in the same manner as the other hydrogen bands with reference to their normal positions. It was accompanied on the more refrangible side by its corresponding dark band. A very bright and broad band in the orange, presumably due to sodium radiations, was crossed by two apparently monochromatic dark lines. These were identified as D_1 and D_2 . To the violet of this band was the usual absorption. It covered the normal position of D_3 , but there is no reason to suspect that it related to the element helium. Besides the five well-known Nova bright bands in the region of λ 4860 to λ 5270 no further details could be observed visually, on account of the strong continuous spectrum, which masked the fainter bands.

The spectrograms obtained on February 25th extend from λ 3830 to λ 5700. One of these, enlarged 7-fold, is reproduced in the accompanying sheet of illustrations, Figure 1. Immediately below the reproduction is an intensity curve, Figure 2, drawn after a comparison of all the plates of the evening. The results of the measurements of two of the plates are contained in TABLE I.

TABLE I.

Feb. 25.		DESCRIPTION.
2024D	2026D	
	λ 3829	} Very faint bright band.
	3840	
	3834.4	Suspected dark line.
	3851	} Bright band.
	3862	
	3871	
	3917	Minimum of broad absorption band.
	3933.80	Strong dark line (K).
	3939	Maximum of bright band.
	3952	Minimum of broad absorption band.
	3955	Beginning of bright band.
λ 3968.54	3968.31	Rather faint dark line (H).
	3989	End of bright band.
4078	4081	} Slight absorption.
4086	4087	
	4094	Bright band.
4141		Bright band.
4155	4158	} Bright band.
4174	4172	
4198		
	4211	Minimum.
4217	4218	} Bright band.
4274	4270	
	4277	Minimum.
4308		Slight maximum.

4316	4318	} Absorption.
4324	4326	
4335		} Max. } Bright band.
4367	4376	
4482		Beginning of bright band.
4387		Slight maximum.
4404		} Slight maximum.
4416		
4418		End of band.
4429		Minimum.
4432	4442	} Maximum.
4459	4450	
4466		} Minimum.
4470		
4480		} Maximum, double (?).
4497		
4510		Maximum.
4510		Very narrow maximum.
4543	4453	} Max. }
4555		
4569		} v. f. }
4587	4584	
4591		} Max. }
4626	4626	
4667	4672	} f. }
4687	4690	
	4626	Maximum of diffuse bright band.
	4672	Maximum of very faint bright band.
	4690	Suspect minimum.
	4803.0	} Broad absorption line.
	4808.2	
	4833.7	} Broad absorption line.
	4840.6	
4854	4853	} Max. }
	4905	
	4918	Maximum of bright band.
	4951	End of bright band.
	4992.7	} Broad absorption line.
	5000.1	
	5015	Maximum of bright band.
	5051	End of bright band.
	5111	Beginning of brightening.
	5138	} Absorption band.
	5152	
	5179	Maximum of bright band.
	5213.9	Minimum.
	5231.8	Maximum.
	5255.1	Minimum.
	5272.6	Maximum.
	5294.8	Minimum.
	5305	Suspect slight maximum.
	5326	Maximum.
	5337	End of band.
	5409	} Bright band, v. faint.
	5443	
	5509	Rather narrow dark line.
	5511	} Max. }
	5523	
	5566	

These maxima make up a broad band.

Perhaps the most striking features of the plates are the broad, bright and dark H and K bands, the bright components being crossed by fine dark H and K lines. The band at H is evidently the result of the superposition of the H_ϵ (hydrogen) and H (calcium) bands. The fine H line is apparently not so black as the K line, though allowance must be made for the different densities of the negative at the two places.

The violet edges of the bright bands are the more sharply defined, except for the K band, in which the reverse is the case. The hydrogen bands are very broad and diffuse, and it is difficult to locate the positions of maximum with accuracy. There seems, however, to be a decided shift of the maxima to the violet of the normal positions of the hydrogen lines, by an amount greater than the probable error of measurement. In the following table the first column contains the normal positions of the hydrogen lines, the second and third the observed positions of maxima taken from TABLE I, and the fourth the displacement of the maxima in tenth meters:

λ (normal)	λ in Star	$\Delta\lambda$
4102	4094	— 8
4341	4335	— 6
4862	4853	— 9
		— 8

The next photographs with the same apparatus were secured on March 15th, by which time the spectrum had greatly changed. These changes appear to be more pronounced in the photographs taken on March 18th, and these two sets will be considered together. The results of the measures are contained in TABLE II.

TABLE II.

March 13.	March 18.	
2049C	2057D	DESCRIPTION.
λ 3866.79		Narrow dark line.
3869.87	λ 3870.0	Narrow dark line.
3878	3874	Maximum } Bright band ($H\zeta$).
3896	3892	
3912	3910	
3933.89	3933.67	
	3945	Apparent beginning of bright band.
3945.2	3945.7	Fine dark line.
3946.9		Fine dark line.
3950.37	3950.16	{ Strong dark line. Width in 2057 D = 0.9 t. m.
3968.40	3968.62	Narrow dark line (H).
3974	3975	Maximum of bright band ($H\epsilon$).
3987	3991	End of band.
	4068	Beginning of bright band.
4075.3	4074.6	Dark line.
4078.0	4077.4	Dark line.
4081.35	4081.32	{ Strong dark line. Width in 2057 D = 1.3 t. m.
4105	4108	Maximum of bright band ($H\delta$).
4128	4131	End of band.
	4171	Maximum of very faint bright band.
	4219	} Very faint bright band.
	4244	
	4303	
	4310.2	Faint fine line.
4312.7		Faint fine line (suspected).
4315.0	4314.2	Faint fine line.
4318.42	4318.55	{ Strong, well-defined dark line. Width in 2057 D = 0.9. t. m.
4342	4347	Maximum of bright band ($H\gamma$).

4366	4368	End of band.
	4454	} Very faint and diffuse bright band.
	4490	
	4515	Maximum of suspected bright band.
	4820	Beginning of bright band.
	4826	First maximum of bright band.
	4828	Suspect dark line.
	4832.7	Faint dark line.
4835.0	4836.5	Strong dark line. Width = 1.9 t. m.
4862	4868	Maximum of bright band ($H\beta$).
4907	4900	Beginning of bright band.
4916	4914	Maximum.
4946	4943	End of band.
5015	5005 $\pm$	Maximum of bright band, just visible.

The spectrograms of March 13th show the K band to have disappeared. Most probably the H band shared a similar fate, though it is impossible to prove this, on account of the superposition of the $H\epsilon$ band, referred to above. The fine H and K lines remain, but the absorption in the former appears to be less complete than before. The maxima of the bright hydrogen bands are shifted toward the red from the normal positions of the hydrogen lines. The amount of this shift, taken from TABLE II, is as follows:

Line.	Mar. 13.	Mar. 18.
$H\zeta$	+ 7 t. m.	+ 3 t. m.
$H\epsilon$	+ 4	+ 5
$H\delta$	+ 3	+ 6
$H\gamma$	+ 1	+ 6
$H\beta$	+ 1	+ 7
(Means)	+ 3	+ 5

The bands are so diffuse that the position of maximum in any one case is uncertain to the amount of several tenthmeters. It is certain, however, that there is a displacement in the direction mentioned.

It is in the dark bands accompanying the bright ones that the changes are most marked. The former broad, diffuse, absorption bands are replaced by multiple fine lines. Of these lines, the one of greatest wave length is many times the most intense, and practically terminates the bright band with which it is associated. Two other lines were observed with certainty in many of the groups, and were suspected in all the groups, except $H\zeta$, where the spectrum was too faint for reliable observation.

The displacements of the principal dark lines from the normal positions of the hydrogen lines vary considerably from one end of the spectrum to the other, but seem to be very approximately proportional to the wave-lengths. In the following table the means of the displacements for the two dates are given in the second column, while those computed on the assumption of direct proportionality to the wave lengths are

given in the third. The assumed proportion is represented by the equation $\Delta\lambda = 0.00505 \lambda$.

Line.	$\Delta\lambda$		O—C	Wt.
	Observed.	Computed.		
H_{ζ}	19.28 t. m.	19.64 t. m.	— 0.36 t. m.	1
H_{ϵ}	20.04	19.98	+ 0.06	1
H_{δ}	20.51	20.79	— 0.28	1
H_{γ}	22.18	22.91	+ 0.27	1
H_{β}	25.7	24.5	+ 1.2	$\frac{1}{2}$

The wave-lengths in the neighborhood of H_{β} can not be determined with great accuracy from these plates, on account of both the relatively low dispersion in that region of the spectrum, and the unsatisfactory nature of the comparison lines available for measurement. In the determination of the constant of proportionality the H_{β} result was therefore given weight one-half. Considering the unsymmetrical distribution of light on the two sides of the absorption lines, it is safe to say the residuals (O—C) are commensurate with the errors of measurement. The proportionality of the displacements of the dark hydrogen lines to their wave lengths therefore appears to be a fundamental characteristic of the star's spectrum at this stage of its development.

We shall refer to the displacements of some of the other dark lines, the origins of which are open to little doubt. While the dark H and K bands were in evidence, they were displaced toward the more refrangible end of the spectrum by about 16.5 t. m. On account of the breadth of the bands, the measured displacement is liable to an error of perhaps two tenth meters. The displacement computed by means of the proportionality assumed above is 20 t. m. The displacement of the dark D band (due to sodium) which will be referred to below is 27 t. m. The error of measurement of the position of this band is influenced by its breadth, and to some extent by the sensitiveness curve of the "isochromatic" plate used, which is very steep in this region of the spectrum. The tendency would be to make the measured displacement smaller. The computed displacement is 30 t. m.

The computed displacements given above depend, as has been said, on measurements of the fine hydrogen lines which developed after the calcium bands had disappeared, and probably after the spectrograms of the D band had been secured. It might therefore seem more reasonable to compare the displacements of the calcium and sodium bands with those of the diffuse bands of hydrogen which existed simultaneously

with them, and resembled them somewhat in their general characteristics. The displacements of the hydrogen bands are:

Line.	$\Delta\lambda$
H_{δ}	— 19 t. m.
H_{γ}	— 19
H_{β}	— 24

From these we obtain the equation $\Delta\lambda = 0.0046 \lambda$. The observed displacements, and those computed on this basis, are:

Line.	$\Delta\lambda$	
	Observed.	Computed.
K	— 17 t. m.	— 18 t. m.
H	— 16	— 18
D	— 27	— 27

The agreement is closer than that resulting from the first assumption. There is then no evidence that the position of the bands is affected by other considerations than that of wave length.

The other features of the spectrum are shown in the reproduction of one of the plates of March 18th, Figure 3, directly enlarged from the original negative; and still better by the intensity curve subjoined, Figure 4.

The drawings of the intensity curves for February 25th and March 18th are not strictly comparable on the red side of H_{β} , for the reason that the plates used on the two dates were of different character. The earlier spectrogram was made on a Cramer Isochromatic plate, and the late one on an ordinary Cramer Crown, a plate not sensitized to the lower rays. The isochromatic plate is of reduced sensitiveness in the region $\lambda 4800$ to $\lambda 5400$; and in constructing the intensity curve the observer increased the ordinates in this region somewhat arbitrarily, but in accordance with his judgment. In all of the plates secured on March 13th and 18th, the region $\lambda 4600$ — $\lambda 4700$ was over-exposed, and the details thereby destroyed.

During the early part of April the appearance of the spectrum was as is indicated in Figures 5 and 6, and in Table III. The triple absorption lines referred to above had so decreased in intensity as to make their recognition very uncertain. A broad and diffuse absorption had developed in the neighborhood of the normal position of the three principal hydrogen lines. H_{ζ} is just on the limit of visibility on the photographs and no details can be observed with certainty in that region. The spectrogram of April 5th was made on a Cramer Isochromatic plate, as was also that of February 25th, so that the two should be comparable.

TABLE III.

Apr. 1.	Apr. 5.	DESCRIPTION.	
2064D	2067D		
λ 3956	λ 3959	}	v. f. bright band (H_{ϵ}).
3986	3982		
3968.1	3968.5	Dark line, very poor (H).	
4079	4079	}	Diffuse absorption, very faint.
4097	4097		
4103	4109		
4126	4126		
4318	4317	}	Diffuse absorption, very faint.
4335	4337		
4340	4349		
4344	4349		
4365	4368	}	Bright band (H_{γ}).
4457	4456		
	4461	Max. }	Bright band.
4492	4489		
	4523	Center of very diffuse bright band.	
4508		}	Suspected v. f. bright band.
4536			
	4555	}	Maximum of rather faint bright band.
	4562		
4583		Maximum of suspected faint bright band.	
	4600	Suspected minimum.	
	4607	Max. }	Bright band. }
	4629		
	4660		
	4660		
4632		}	Bright band.
4661			
	4667	Max. }	Bright band.
	4675		
	4683		
4699		Max. of v. f. bright band, just visible.	
4847	4837	}	Diffuse absorption, v. f. and uncertain.
	4855		
	4861		
	4869		
4881	4882	Bright band (H_{β}).	

It was not possible to observe the star every night over a long period of time, for the purpose of detecting rapid variations in the spectrum: such ones, for instance, as might accompany the more or less periodic changes in the star's brightness. In general, it was noticed during the spring months that the bright bands were relatively more intense at minima than at maxima of the star's brightness; that is, that the variations affected the continuous spectrum more than the bright lines. We recognize that physiological effects may play an important part in such estimates, however. Definite changes certainly occurred between April 1st and 5th. The bands λ 4629 and λ 4675, appearing on the spectrogram of April 5th, are not on that of April 1st; and the bands of April 1st at λ 4583 and λ 4632-4661 are not recorded on that of April 5th. The band at λ 4675 was too faint to record itself on the earlier photograph. The changes described could be caused by variations in the relative intensities of one or two of the bands concerned.

The absence, in Sumatra, of the principal parts of the large visual spectroscope, prevented visual meas-

urements of the spectrum. There was little need for these, however, as the isochromatic plates afforded vastly more valuable observations down to and including the D region; and the H_{α} band was photographed with erythro plates, as well as observed visually. In February, no bright bands were visible except those which have been mentioned above, or described in the tables. As the star grew fainter, additional bands were observed. At the times of the last visual observations, on April 14th and 21st, essentially all the bands observed in the early spectrum of Nova Aurigæ were present. Those at λ 5760, λ 5840, λ 6160 and λ 6300 were easily seen. The last photographic observation was secured on April 14th.

The spectrum was observed visually on two evenings, with instrument I, for the purpose of determining whether the light of the star was polarized in any manner. The slit was opened wide, and a Nicol prism was held in front of the eyepiece. As the prism was rotated, no narrowing of the lines, or other phenomena, were observed, except a slight darkening of the spectrum as a whole, due to the polarizing effect of the spectroscope. The results furnish no evidence of a ZEEMAN effect in the star, but in some respects the evidence is merely of a negative character.

The velocities in the line of sight determined from measurements of the fine dark H and K calcium lines on all the plates secured up to and including March 18th, with spectrograph I, are contained in the following table:

Date.	Plate No.	Velocities.	
		H	K
Feb. 25	2023C	— 4 ^{km}	+ 6 ^{km}
	2025C	+ 2	+ 5
	2026D	—	+ 13
Mar. 13	2049C	— 6	+ 13
	2050D	+ 22	— 4
Mar. 18	2056C	—	+ 14
	2057D	+ 7	+ 7
	Means	+ 4.2	+ 7.7

These values are corrected for the orbital motion of the earth, but not for diurnal motion and the curvature of the spectrum lines. These corrections are — 0.2^{km}, and — 0.3^{km}, respectively. Applying them to the mean of the individual determinations, we have + 5.7^{km} per second as the observed radial velocity of the star. This value was used in correcting all the wave lengths determined with spectrograph I.

Recalling that the above individual results depend each upon measures of a single line, on plates secured with an instrument containing only one light flint prism, whereas the current results with the MILLS Spectrograph depend upon measures of many lines dispersed by three dense flint prisms, the linear values of the discrepancies are seen to be small.

A spectrogram of the H and K region secured on March 5th with spectrograph IV yielded the following velocities, from the fine dark lines:

$$\begin{array}{r} H, +6.5^{\text{km}} \\ K, +8.1 \\ \hline \text{Mean, } +7.3 \end{array}$$

A discrepancy of 2.5^{km} at $H\gamma$ corresponds in linear value to 1.8^{km} at H .

These dark lines were very narrow. Their measured widths on the above plate were 0.22 t. m. and 0.28 t. m., respectively, including the effects of flexure of the instrument in broadening the lines.

Figure 9 is a reproduction of the H and K region recorded with spectrograph I on February 25th.

Spectrograms of the D region were secured on February 26, 27, 28, March 3, 14, and 17, with either low or high dispersion. While some of the low dispersion plates are quite satisfactory, those of high dispersion are so much more so, that results from the high dispersion alone will be considered. Two of the latter were obtained on February 28th and March 3d. Reproductions of them are given in Figures 7 and 8, respectively. The position of maximum is apparently to the violet of the D absorption lines; but the slope of the sensitiveness curve of the plate, referred to above, would have a very strong tendency to shift the apparent maximum to the violet, so that it is impossible to locate the actual position of greatest intensity.

The radial velocities of the Nova determined from the D lines on these plates are as follows:

Date.	Plate No.	Velocity. D_1	Velocity. D_2	Mean.	Corr. for Curv.	Red. to Sun.	Velocity.
Feb. 28	2034C	+38.7	+33.8	+36.1	-2.7	-27.3	+6.1 ^{km}
Mar. 3	3040D	+33.8	+25.8	+29.8	-2.3	-27.0	+0.5

Mean velocity with reference to Sun, $+3.3^{\text{km}}$

In comparing these results for the D region with those secured from ordinary line-of-sight work in the violet region, it is necessary to bear in mind the matter of relative prismatic dispersion for the two regions. In the MILLS Spectrograph work at $H\gamma$, we should be satisfied if the discrepancy between the values secured from two plates, on each of which only two lines had been measured, were less say than $2\frac{1}{2}$ kilometers per second. The linear value of the discrepancy between the above results, $6.1 - 0.5 = 5.6^{\text{km}}$, would correspond to 2.4^{km} at $H\gamma$ with the MILLS Spectrograph.

As a check on these results, the D lines were measured on a spectrogram of the planet Mars, taken under similar conditions. The difference between the observed and computed velocities, -2.2^{km} , corresponds to -1.0^{km} at $H\gamma$, and is satisfactory.

The D absorption lines are very narrow. A comparison of their widths with those of the corresponding lines in the solar spectrum is not without interest.

A measurement of one of the plates places their width at 0.8 t. m. The width of the solar lines according to ROWLAND'S tables is 0.17 t. m. It was considered better, however, to compare the two spectra under the same instrumental conditions. The widths of the D lines on a spectrogram of Mars and on one of the Sun were therefore measured, with the following results:

Line.	Mars.	Width in Sun.	Nova.
D_1	1.0 t. m.	0.9 t. m.	0.8 t. m.
D_2	1.2	1.1	0.8

The solar and planetary lines are probably somewhat broadened by the presence of unresolved companions, but it is evident that the breadths in the two cases are of the same order. The last spectrogram of the D region, secured in the spring, was a low dispersion one taken on March 17th. It showed the general features to have remained practically unchanged.

For convenience, the determinations of radial velocity referred to above are here collected:

Spectrograph I, H and K , $+5.7^{\text{km}}$
 Spectrograph III, D_1 and D_2 , $+3.3$
 Spectrograph IV, H and K , $+7.3$

In addition to the spectrograms on which these results depend, a number of others recorded the absorption lines of sodium and calcium. Within the limits of error of measurement, all give accordant results. There is no evidence that the velocity is variable; and this view is strongly confirmed by the results of the summer series of observations, to be described below.

Spectroscopic observations of Nova Persei were discontinued from April 21st to July 9th, while the Sun was passing through this region of the sky. Our regret that the southern position of the Lick Observatory prevented observations in this period is coupled with the hope that the observatories of northern Europe were able to obtain a practically continuous series.

Our summer series of observations has been secured mainly with spectrograph 1. The first observation of the series was made on July 9th. As announced by Professor Pickering, the spectrum at this time was that of a nebula. The usual nebular lines are represented by broad bright bands. The several spectrograms obtained at well distributed intervals since July 9th do not show that any pronounced changes have occurred in this time. The results of the measurements of four of the plates are contained in TABLE IV. An ordinary plate, No. 2198C of July 15th, and an isochromatic plate, No. 2223D of August 11th, with their corresponding intensity curves, are reproduced in Figures 10, 11, 13 and 14, respectively.

TABLE IV.

July 15. 2198 C.	July 16. 2199 D.	July 24. 2205 E.	Aug. 11. 2223 D.	DESCRIPTION.
λ 3855		λ 3854	.....	Beginning of bright band.
3858.3		3858.3	.....	Absorption line.
3860.3		3860.1	.....	Maximum of bright band.
3864.0		3864.2	.....	Broad absorption line.
3869.7		3869.7	.....	Broad and hazy absorption line.
3874.9		3875.0	.....	Absorption line.
3878.9		3879.0	.....	Absorption line.
3885		3885	.....	End of brighter part of band.
.....		3890	.....	End of band.
.....		3947	.....	Beginning of bright band.
3953		3953	.....	Beginning of brighter part of band.
3959.1		3959.0	.....	Maximum of bright band.
3962.6		3962.8	.....	Broad absorption line.
3968.64		3968.71	.....	Strong and narrow absorption line (<i>H</i>).
3971.4				Suspect absorption line.
3984		3984	.....	End of brighter part of band.
.....		3988	.....	End of band.
.....		4056	.....	Beginning of brightening.
4088		4084	.....	Beginning of brighter part of band.
4093.5		4093.9	.....	Maximum of bright band.
4097.1		4097.2	.....	Rather broad absorption line.
.....		4108.5	.....	Absorption line.
4118		4120	.....	End of band.
4325		4324	.....	Beginning of bright band.
4331.5		4330.9	.....	First maximum.
4335.5				Rather narrow dark line, absorption incomplete.
4349		4348	.....	Beginning of second brightening.
4353.2		4353.9	.....	Second maximum.
4357.9		4358.2	.....	Absorption line.
4364.6		4364.7	.....	Diffuse absorption line.
4385		{ 4381	.....	End of brighter part of band.
.....		{ 4390	.....	End of band.
4456		4455	.....	Beginning of bright band.
4462		4462.0	.....	Maximum.
4466		4467.1	.....	Absorption line.
.....		4472.1	.....	Suspect absorption.
4488		4489	.....	End of band.
4497		4499	.....	Beginning of faint diffuse bright band.
4523				Diffuse maximum.
4548		4549	.....	End of band.
4557				Beginning of suspected faint band.
4561		4559	.....	Maximum.
4568				End of band.
4590		4594	.....	Beginning of faint brightening.
.....		4600	.....	Maximum.
4613		4609	.....	End of brightening.
4615		4618	.....	Beginning of bright band.
4623				Suspect faint maximum.
4632			λ 4631.2	Principal maximum.
4635			4633.8	Absorption line.
4661		4656	4656	End of band.
4669		4670	.....	Beginning of bright band.
4676		4675.5	4675.4	First maximum.
4681		4680.5	4680.6	Absorption line.
4689			4687.0	Absorption line.
4696		4695.7	.....	Absorption line.
4698		4698	4698.1	Beginning of what is evidently a superposed band.
4703		4702.3	4703.0	Second maximum.
4708		4707.9	4708.7	Hazy absorption line.
4714		4713.2	4713.8	Third maximum, stronger than preceding ones.
.....		4717.8	4719.5	Absorption line.
.....			4725.7	Absorption line.

TABLE IV.—CONTINUED.

July 15. 2198 C.	July 16. 2199 D.	July 24. 2205 E.	Aug. 11. 2223 D.	DESCRIPTION.
4736	.....	.....	.....	Absorption line.
4748	.....	4745	4742	End of band.
4845	.....	4846	4846	Beginning of band.
4849	.....	.....	.....	Absorption line.
4852	.....	4853.2	4850.0	Maximum.
4856	.....	4855.7	4854.8	Absorption line.
4862	.....	4862.7	4862.1	Absorption line.
4869	.....	.....	4868.4	Absorption line.
4873	.....	.....	.....	Suspect absorption line.
4880	.....	4879	4878	End of band.
4945	.....	4944	4942	Beginning of bright band.
4948	.....	4947.7	4946.8	Maximum.
4954	.....	4952.2	4952.6	Absorption line.
4961	.....	4960.3	4959.0	Absorption line.
4968	.....	.....	4966	Suspect absorption line.
4976	.....	4979	4978	End of band.
4989	.....	4990	4987	Beginning of bright band.
4992	.....	.....	.....	Suspect absorption line.
4996	.....	4995.4	4994	Maximum of bright band.
5001	.....	5000.6	.....	Absorption line.
5008	.....	5008.2	.....	Absorption line.
5016	.....	.....	.....	Suspect absorption line.
5027	.....	5026	5027	End of band.
.....	λ 5038	.....	.....	Absorption line.
.....	5040	.....	5039	maximum } Faint bright band ¹ , which possibly runs back to preceding band.
.....	5049	.....	.....	
.....	5067	.....	5070	
.....	5136	.....	5137	maximum } Bright band ¹ .
.....	.....	.....	5168	
.....	5201	.....	5199	maximum } Bright band ¹ .
.....	5264	.....	5259	
.....	5297	.....	5298	
.....	5312	.....	5317	maximum } Bright band ¹ .
.....	5389	.....	5393	
.....	5414	.....	.....	
.....	5433	.....	5438	} Difficult bright band ¹ .
.....	5513	.....	5513	
.....	5548	.....	5562	
.....	.....	.....	5603	Maximum of very difficult bright band, broad and diffuse ¹ .
.....	5652	.....	5651	
.....	5671	.....	.....	maximum } Bright band ¹ .
.....	5713	.....	5716	
.....	5733	.....	5735	Beginning of bright band.
.....	5741	.....	5741	Maximum.
.....	5746	.....	5747	Absorption line.
.....	.....	.....	5764	Suspect absorption line.
.....	5769	.....	5770	Absorption line.
.....	5778	.....	5776	End of band.
.....	5856	.....	5857	Beginning of bright band.
.....	5863	.....	5862	Maximum.
.....	5869	.....	5867	Absorption line.
.....	5877	.....	5878	Absorption line.
.....	5890	.....	5890	Absorption line (D_2).
.....	.....	.....	5895	Absorption line (D_1).
.....	5896	.....	5896	End of band.

¹ These bands are very diffuse. The determinations of wave length are therefore uncertain to the extent of several tenth meters.

The H_α band is very bright, but no other details additional to those on the photographs have been shown by the visual observations.

A striking feature of the spectrum is the distribution of the light in most of the bands. In general, there is a maximum, considerably displaced to the violet of the normal position of the nebular line. This maximum is accompanied on its less refrangible side by a pronounced minimum. In most cases another minimum appears to the red of this, and in some of the bands there are additional minima. The one nearest to the maximum is in each case the strongest. While we have, of course, no knowledge as to the origin of these minima, their appearance certainly suggests that they are absorption phenomena, and they will be referred to as such. Though most of the bands conform to a general type, they are not by any means duplicates of one another. In some cases the principal absorption line alone was identified with certainty, while in others, lines apparently not belonging to the series were strongly suspected. In a number of instances the appearance of the bands was indicative of such complexity of structure as to make it impossible to consider more than their general features in a preliminary study of this sort. It is quite possible that some of the absorption lines are due to gases in the atmosphere of the star which are not directly involved in the production of the bands. In fact, this actually occurs in the case of the D sodium lines and the H calcium line. The latter appears as an absorption line in the band $\lambda 3947$ – $\lambda 3988$. There is little reason to doubt that its companion, the K line, is absent only by reason of the fact that there the calcium vapor has nothing to absorb.

Another cause of complexity is the overlapping of bands. This occurs in at least three cases:

1.—The bands corresponding to $\lambda 4340.6$ (H_γ) and $\lambda 4363$ (nebular line) are involved in the composite band $\lambda 4325$ – $\lambda 4385$.

2.—Those belonging to the nebular lines $\lambda 4685.9$ and $\lambda 4713.2$ (helium) are superposed in the band $\lambda 4669$ – $\lambda 4746$. There are, in fact, circumstances which indicate the presence of still another component in this band. It will be seen by referring to TABLE IV that there is a maximum at $\lambda 4714$, brighter than the one at $\lambda 4703$, and which cannot be accounted for by the superposition of the two bands to which reference has been made, assuming them to be of normal type. In addition, there are absorption lines at $\lambda 4719$ and $\lambda 4725.7$. These effects would be produced by a superposed band of the regular type corresponding to a line of normal wave length $\lambda 4724$. Moreover, judging from the other bands, the band whose maximum is at $\lambda 4703$ should vanish at about $\lambda 4733$, whereas the composite band in question extends to $\lambda 4746$. The extension may, how-

ever, be due to the nebular line $\lambda 4743 \pm$, the presence of which is partially indicated by an absorption line at $\lambda 4736$. While the complexity of the band is such that a final statement of its composition is impossible without further study, the hypothesis of a line normally at $\lambda 4724$ is advanced as furnishing a plausible explanation of the structure of the broad band.

3.—The band $\lambda 3953$ – $\lambda 3984$ was supposed at first to be the broadened H_ϵ line; but on this supposition the line is unduly strong. The H_γ band is very bright, H_δ is fairly bright, and the $\lambda 3969$ is very bright, whereas H_ζ and the rest of the ultraviolet hydrogen series do not appear. Furthermore, the displacement of the maximum of this band to the violet of the normal position of H_ϵ was greater by about two tenth meters than that of the other maxima in this region of the spectrum. Some spectrograms of well-known planetary nebulae recently secured by Mr. WRIGHT fully explain these peculiarities. In all previous work on the nebulae, the line recorded at this point in the spectrum has been regarded as single, and has been assumed to be H_ϵ . The line is in reality a wide double, as shown in the reproduction of the spectrum of N. G. C. 7027, Figure 12. The component of greater wave length is the H_ϵ hydrogen line, at $\lambda 3970.2$; it is very faint. The more refrangible component, at $\lambda 3967.6$, is much the brighter of the two, and appears to be a characteristic strong nebular line, not previously observed. The positions and relative intensities of these lines leave no doubt that the Nova band at $\lambda 3453$ – $\lambda 3984$ corresponds almost entirely to this nebular line at $\lambda 3967.6$, and is scarcely influenced by the H_ϵ radiations.

In order to investigate the displacements of the maxima of the star bands, from the normal positions of the lines in the nebulae, it was found necessary to make more accurate determinations of the wave lengths of some of the nebular lines than were available. An investigation with that end in view was therefore undertaken by Mr. WRIGHT, and some of the preliminary results will be used in this paper. The following table gives the displacements of the maxima and of the absorption lines of all the bands of the Nova which have been identified as being of nebular origin. The first column contains the normal wave lengths of the lines in nebular spectra, the second the displacements of the maxima, and the third the computed displacements on the assumption of proportionality of displacement to wave length, according to the empirical formula $\Delta\lambda = -0.00212\lambda$. The following four columns contain the measured displacements of the absorption lines which appear to belong to the bands. Positive and negative signs indicate displacements toward the red and violet ends of the spectrum, respectively. Both the maxima and the minima

appear to be displaced in proportion to their wave lengths. The observed widths of the bands are given in the eighth column, as far as they can be determined; but it should be said that the photographic widths are affected both by their intensities and by the sensitiveness curve of the plate. The red edge of the band at $\lambda 5876$ is practically at the limit for isochromatic plates. The wave lengths of the principal bright bands observed in Nova Aurigæ in August 1892 by Mr. CAMPBELL are contained in the last column. That star was of the 10.5 magnitude, and the photographs did not cover the ultra-violet regions.

TABLE V.

Wave lengths in the Nebulæ.	Displacements.						Width of bands.	Prin'l Bands Nova Aurigæ.
	Max. Obs'd.	Max. Com'd.	Min. Obs'd.	Min. Obs'd.	Min. Obs'd.	Min. Obs'd.		
3868.9	— 8.7	— 8.2	—4.8	+0.8	+6.0	+10.0	31	
3967.6	— 8.6	— 8.4	—4.9	+1.1*	(+3.8)		31	
4101.9	— 8.2	— 8.7	—4.8	+1	+7		36	4098
4340.6	— 9.4	— 9.2	—5					4336
4363.3	— 9.7	— 9.1	—5.2	+1.4			33	4358
4471.6	— 9.6	— 9.5	—5	(0)			34	4466
4643±	—11	—10	—8					4630
4685.9	—10	—10	—5	+3		+10		4681
4713.2	—10	—10	—5					471—
4743			—6					
4861.5	— 9	—10	—6	+1	(+7)	(+11)	33	4857
4959.0	—11	—11	—6	+2			34	4953
5007.0	—11	—11	—6	+1			38	5002
5752	—11	—12	—6			+16	43	5750
5875.9	—13	—12	—7	+1			40	
6563†								

Parentheses indicate that the line was only suspected. The absorption in most of the lines is incomplete, so that the bringing out of any particular one is largely a matter of exposure and development. It is quite possible that other lines exist which will appear in a final comparison of all the spectrograms secured.

The nebular character of the Nova spectrum at present is evident from the measures published in the tables, and may be seen at a glance by comparing Figures 10, 11 and 12. All of the principal bands correspond to lines known to exist in the nebulæ.

A comparison of the first and last columns of TABLE V shows that the spectrum of Nova Aurigæ is very closely related to that of Nova Persei. The absence of the bands at $\lambda 4743$, $\lambda 5876$ and $\lambda 6563$ from the former star is no doubt explained by the fact that it was more than four magnitudes fainter than the present star; and it is probable that the bands at $\lambda 3869$ and $\lambda 3968$ were not recorded in 1892 because no auxiliary correcting lens was used to eliminate the chromatic aberration effects of the 36-inch objective. The bands

*The dark line H falls in this place, and determines the exact position measured.

†The very bright $H\alpha$ band was observed visually, but no attempt was made to photograph it in the summer series.

in the present Nova are vastly wider than in that of 1892, and the distribution of light within the bands seems to be different. The positions of corresponding maxima differ about five or six tenth meters in the two cases. Perhaps the most remarkable features of the 1892 spectrum were the bands observed by Mr. CAMPBELL at $\lambda 4358$ and $\lambda 5750$. The $\lambda 4358$ band, in August, 1892, was estimated to be at least eight times as bright as the $H\gamma$ band; but in November, 1894, it had become fainter than $H\gamma$; and the band at $\lambda 5750$, so easily observed in 1892, had become extremely difficult in 1894 (Astrophysical Journal, Vol. I, pp. 49–51). These two bands are now very prominent in Nova Persei; and it is probable that they will diminish in brightness, as in the case of the earlier star. Corresponding to these two bands, there are faint lines in the well-known nebulæ.

The radial velocity of Nova Persei, determined from the H absorption line of calcium, was $+6^{\text{km}}$ on July 15th, and $+12^{\text{km}}$ on July 24th. The mean of the two determinations is in satisfactory agreement with the value, 5^{km} , afforded by the H line in the spring series.

At the time of the spring observations, the D absorption lines occupied positions near the middle of the broad D bright band, as shown in Figures 7 and 8; and the D_3 comparison fell near the more refrangible edge of the band. In the summer observations, the D_3 comparison line, Figure 13, falls near the middle of the bright band, and the sodium comparison lines are situated at the extreme red edge of the band. A long exposure made on August 12th records this bright band to about the wave length $\lambda 5902$, and the sodium D absorption lines are clearly shown to be present. Within the limits of error of measurement, they occupy exactly the same positions as in the spring observations. Corroborative evidence is thereby afforded that the radial velocity of Nova Persei has been practically constant.

It is well known, from the investigations of Runge and Paschen (Astrophysical Journal, Vol. III, p. 4), and others, that the spectrum of helium consists of two sets of lines, and that the relative intensity of the two sets varies with the pressure to which the radiating gas is subjected. Both sets are emitted by a Plücker tube under a few millimeters pressure. The first column of the following table gives the wave-lengths of all the helium lines between $\lambda 3800$ and $\lambda 5900$, described by Runge and Paschen as having an intensity equal to or greater than 3 on a scale of 10. The second column records the intensity. In the third column the Roman numeral I or II indicates that the line belongs to the low or high-pressure series, as the case may be. Each of the sets I and II is subdivided by Runge and Paschen into a principal, a first

subordinate and a second subordinate series. The two subordinate series are indicated by subscripts. The fourth column is self-explanatory.

λ	Intensity.	Series.	Remarks.
3819.8	4	II ₁	Not observed in Nova.
3888.8	10	II	Not observed in Nova.
3964.9	4	I	{ Conflicts with band λ 3855- λ 3885, but probably not in Nova.
4026.3	5	II ₁	Not observed in Nova.
4120.9	3	II ₂	Not observed in Nova.
4388.1	3	I ₁	Not observed in Nova.
4471.6	6	II ₁	Observed in Nova, fairly bright.
4713.2	3	II ₂	Observed in Nova, bright.
4922.1	4	I ₁	Not observed in Nova.
5015.7	6	I	Not observed in Nova.
5875.9	10	II ₁	Observed in Nova, very bright.

It will be seen that the high-pressure series is the only one appearing in the new star, and that even of this series the more refrangible lines are lacking. The maximum of the line λ 3888.8 should lie just within the band λ 3855- λ 3885; but the helium band should extend to λ 3904 if it were present in any strength. It is a significant fact that both sets are present in most of the nebulae, though their relative intensities vary considerably. The evidence of the helium lines would seem to show that the radiation does not take place under exceedingly low pressure.

A number of the bands have recently been photographed with a dispersion of three dense flint prisms. An intensity curve sketched from a MILLS spectrogram of the composite band at λ 435 is reproduced in Figure 15, and the wave lengths of the prominent features are given in the following table:

TABLE VI.
DESCRIPTION.

Sept. 9 2265 D.	
λ 4324	Beginning of bright band.
26.3	Suspect dark line.
28	Beginning of brighter part of band.
28.7	Slight maximum.
29.32	Absorption line.
31.0	Chief maximum of $H\gamma$ band.
32.3	Slightly broadened dark line, or minimum.
33.5	Maximum.
34.5	} Broad minimum.
36.2	
40.49	Narrow dark line.
41.8	} Dark line, broader than preceding.
41.98	
42.2	
43.3	Dark line, broad and diffuse.
44.5	Dark line, broad and diffuse.
47.2	Begining of brightening, due to λ 4363 band.
48.5	Maximum.
49.3	Minimum.

50.5	Maximum.
51.4	Diffuse minimum.
52.3	Maximum.
53.1	Faint minimum.
54.2	Principal maximum of band.
55.0	Slight minimum or dark line.
56.2	Slight minimum or dark line.
57.0	} Broad minimum.
59.0	
60.03	Narrow maximum.
60.49	} Double dark line.
60.92	
63.24	Diffuse dark line.
63.9	Maximum.
64.53	Dark line.
65.0	Suspect dark line.
65.4	Maximum.
65.8	} Double dark line.
66.3	
66.6	Maximum.
67.4	{ Dark line (possibly double, separated by about the same amount as preceding).
68.9	Broad and inconspicuous maximum.
70.2	Diffuse minimum.
72.45	Narrow dark line.
74	} Faint minimum.
77	
4382	End of band.

The bands at $\lambda\lambda$ 3968, 4341, 4363, 4724, 4861, 4959, 5007 and 5752 have been photographed under high dispersion. They all appear to have the same general features, as follows: A pronounced maximum is near the violet edge of the band, flanked on either side by a subordinate maximum. To the red of this group is a broad minimum, or absorption line, while still further to the red is a group of maxima and minima giving the appearance of four absorption lines. With low dispersion this group was observed in most of the bands as a broad and diffuse absorption line (see TABLE V, column 5). Further than to note these general characteristics, the spectrograms referred to have not been studied.

The bearing of the foregoing observations upon the various theories of new stars is reserved for a future paper.

It is greatly to be regretted that the delicate details of the original negatives are so largely lost in the reproductions.

Acknowledgements are due to Dr. H. M. REESE for assistance in taking many of the photographs and in reducing some of the measures.

W. W. CAMPBELL,

W. H. WRIGHT.

September 12, 1901.

NOTE ON THE SPECTRUM OF NOVA PERSEI

At the request of the Director, and with the assistance of Fellow R. H. CURTISS, I secured several spectrograms of Nova Persei with the CROSSLEY Reflector during September. The spectrograph used was the small one designed by the late Director KEELER. It has been modified by Fellow H. K. PALMER to receive a prism and lenses of quartz, and has been extensively used by him.

On the plates taken are the nine bands observed between λ 387 and λ 501 by Messrs. CAMPBELL and WRIGHT. In addition to these are two bright bands far up in the ultra-violet. The provisional wave lengths of these new bands are λ 346 and λ 339. The one at λ 346 is very bright, being surpassed on these plates only by the band at λ 387. It is brighter than the band at λ 397, even though the latter is in a region of greater sensitiveness for ordinary dry plates, and the light of the latter is not so strongly absorbed by the earth's atmosphere.

The new band at λ 339 is fainter than the integrated bands near λ 471, but stronger than the band at λ 464.

The band at λ 346 coincides in position with a line which Mr. PALMER has discovered in some of the well-

known nublæ during the past summer. This strengthens the conclusion that the spectrum of the Nova is nebular. It is probable that the band at λ 339 corresponds to an undiscovered nebular line.

After these results were secured, Professor MAX WOLF's article in the *Astronomische Nachrichten* No. 3736 arrived at Mt. Hamilton. His observations demonstrate, without need of further proof, that the recently reported halo around the Nova is purely of instrumental origin. It is undoubtedly true that the chromatic aberration effect, thus observed by Professor WOLF, is due to the ultra-violet bands described above, and especially to the band at λ 346. Professor WOLF's objectives seem to be very transparent, as is shown by the fact that these radiations were able to pass through them at all. His objective *b* evidently transmits them more freely than does objective *a*. If the halo were due to the band at D_3 it should be of practically the same intensity with both objectives.

JOEL STEBBINS.

September 23, 1901.