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SPECTROSCOPIC NOTES.

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THE HARVARD STAR, Z CENTAURI.

IN December 1895, the *H. C. O. Circular* No. 4 announced that a "new star" had just been discovered by Mrs. Fleming, from an examination of the Draper Memorial photographs taken at Arequipa, Peru. The *Circular* stated that the star was situated very near the nebula *N. G. C.* 5253; that no trace of the star could be found on 55 plates taken from 1889 May 21 to 1895 June 14; that its magnitude on 1895 July 8 and July 10 was 7.2, and on 1895 December 19 was about 11; that an examination with a prism on December 19 showed that the spectrum was monochromatic, and closely resembled that of the adjacent nebula; and that, like the new stars in Cygnus, Auriga and Norma, this star appeared to have changed into a gaseous nebula.

The star was at once observed at Mt. Hamilton. It was found to follow the nucleus of *N. G. C.* 5253 by $1^s.4$ and was north of it 18″. Its position for 1875.0 was[1]

$$\alpha = 13^h\ 32^m\ 51^s.9, \quad \delta = -30^\circ\ 59'\ 58''.$$

On the nights of 1895 December 22 and 29 I examined the

[1] *Ast. Jour.*, **16**, 85.

spectrum of the star—then 11.2 magnitude—and was reasonably certain the spectrum was continuous, but the seeing was too poor to permit a definite decision. It was certainly not nebular. On the morning of February 8, 1896, the conditions were good, and I carefully examined the spectra of the star and the adjacent nebula, using the large spectroscope and 60° crown prism. The nebula's spectrum was of the usual type, the lines at $\lambda\lambda$ 5007, 4959 and 4862 having their usual relative intensities. The line near λ 4690 seemed to be present, as in the case of *N. G. C.* 7027 and *G. C.* 4964. The spectrum of the Harvard star was *continuous*, though very peculiar. The maximum visual intensity was in the yellow-green, the green-blue was very faint, while the blue was surprisingly strong. In fact, the blue was very much brighter visually than the green-blue. The spectrum was relatively very faint from about λ 5200 to λ 4600. There was no trace of the nebular lines visible, nor of the $H\beta$ line. There was some evidence of bright lines or of irregularities in the brightest portions of the spectrum, but the light was too weak to enable me to decide. The slit was at right-angles to the line joining the star and the nebula. By pressing against the telescope the two spectra were alternately brought into view. The nebular spectrum thus formed a good basis of comparison, and the star spectrum in no wise resembled it.

The Harvard observation of the spectrum was made on December 19 with the 15-inch telescope, when the star was of the 11th magnitude, very low in the sky and near the Sun. The continuous spectrum under such circumstances would be exceedingly faint. The star and nebula are less than 30″ apart. Is it not possible that the observed spectrum was that of the nebula, and not that of the star?

On June 11, 1896, Professor Hussey observed that the star had decreased in brightness to 14.4 magnitude, and that it was surrounded by a faint, irregular nebula which seemed to extend continuously to the main nebula south preceding. On July 9 he observed the star to be of the 16th magnitude, and the nebulosity surrounding it was plainly seen to be continuous with the bright adjacent nebula, *N. G. C.* 5253. That the nebulous background was not seen earlier was probably due to the overpowering light of the star. On January 4, 1897, Professor Hussey looked for the star, without success: it was fainter than 16¼ magnitude, and invisible.

Some writers have contended that this star is not a "new star," but that it is identical with *Cord. DM.*—31°10536,[1] observed on four nights in 1885–92 at Cordoba. While I do not want to enter upon a discussion of this question—at present unsolved and not now capable of solution, apparently—I may perhaps express my opinion that all the evidence available points to the identity of the nebula *N. G. C.* 5253 and the star *Cord. DM.*—31°10536. The evidence that the Harvard star was observed previous to 1895 July 8 is confined to the single Cordoba date, 1887 April 12.

If the star is simply a variable, as some writers contend, its period must be very long, or its variations very irregular.

If the star is to be classed with the "temporary" stars, it is not analogous to the new stars in Cygnus, Auriga and Norma, but rather to the star of 1885 in the Andromeda Nebula.

THE SPECTRUM OF MARS.

My visual spectroscopic observations of Mars and the Moon in 1894, under extremely favorable circumstances, led me to conclude that the two spectra were apparently identical, so far as visual estimates of the intensities of the telluric lines were concerned. My paper on the subject stated the conclusions to be drawn from the observations as plainly as it would be possible even now to state them. Nevertheless, they were misunderstood persistently by many reviewers, and I beg to re-state them here, viz.:

While the polar caps are conclusive evidence of the presence of atmosphere and vapor (probably water-vapor) on Mars, yet these do not seem to exist in sufficient quantities to have been detected by any spectroscopic observations thus far made; and

[1] *Ast. Jour.* **16**, 16, 106, 165, 166.

my observations indicate that the density of the atmosphere at the surface of Mars is not more than half as great as the density of our atmosphere at the summit of the Himalaya Mountains.

Thus far, all the observations were visual, though there were plates sensitive to the light from the region of the important δ vapor band. In March 1895 I obtained a few photographs of the spectra of Mars and the Moon, on Cramer's isochromatic plates, using the large Brashear spectroscope and a 60° crown prism. The photographs covered the region of the δ band. There was no visible difference in the spectra of the two objects, though the conditions were not first-class.

On October 22, 1895, using the apparatus described above, I obtained a long series of photographs of both spectra. The dew-point for the night was 0° Centigrade. Some of the negatives were copied on lantern-slide plates, for the purpose of increasing the contrasts in the spectra. Neither the original negatives, nor the positives on slow plates, revealed any differences in the two spectra. However, a comparison of the plates corresponding to high and low altitudes, convinced me that the photographic method *with low dispersion* is not so sensitive as the visual method with the same dispersion. On December 18, 1896, I obtained a few photographs, using a fourth-order grating. It was necessary to use a rather wide slit, and the negatives were considerably underexposed, though comparable in the δ region. There was no visible difference in the spectra, but the result is purely negative, for two reasons: (*a*) The negatives are not as dense as they should be; and (*b*) I was unable to secure photographs at low altitudes, to test the sensitiveness of the method. I believe the photographic method with high dispersion is fully as sensitive as the visual method with low dispersion; but to what extent it is more sensitive I cannot say. A train of three flint prisms would have been much more efficient than the grating, but such a train was not available.

There has been some discussion as to whether high or low dispersion should be used in such a problem as this. Not to enter upon a consideration of the general question, I may perhaps make one or two remarks. In the photographic study of a spectrum, such as that of Mars, the question of brightness does not enter, except as it affects the exposure time. When the visual method is used, the question of brightness does enter. It is then a question of getting *a little something* with low dispersion, or *nothing at all* with high dispersion. It has been my experience that those who have not observed spectra at night invariably overestimate the brightness of those spectra.

COMET 1895 IV (PERRINE).

Visual observations on November 17, 1895, showed the yellow, green and blue bands of carbon, with their usual relative intensities, together with a strong continuous spectrum.

A photograph taken December 8, 1895, showed the following features:

The blue carbon band, unresolved, maximum near λ 4690.

λ 4366 bright line, easy.
λ 4313 " " faint.
λ 4298 " "
λ 4214 " " very easy, cyanogen.
λ 4196 " " easy, cyanogen.
Traces of several bright lines between $\lambda\lambda$ 4100–4000 (cyanogen ?).
λ 3881 brightest line on plate, cyanogen.
λ 3870 very bright line, cyanogen.

Continuous spectrum between $\lambda\lambda$ 4700–4000, which has a fluted appearance, as if caused by the principal groups of absorption lines in the solar spectrum, notably the group at G.

COMET 1895 V (BROOKS).

On November 22, 1895, visual observations showed that the spectrum was of the usual character. The spectrum was too faint to photograph.

COMET 1896 I (PERRINE).

On February 19, 1896, the visual spectrum was of the usual character. A photograph recorded the bright cyanogen lines at λλ 3881 and 3870. No other lines were recorded, on account of the faintness of the comet, which was not visible to the naked eye.

COMET 1896 III (SWIFT).

On April 30, 1896, the visual spectrum was of the usual char acter. The spectrum was too faint to photograph.

COMET 1889–96 (BROOKS-JAVELLE).

Visual observations were made on August 15, and October 6, 1896. The comet was about 13th magnitude. The continuous spectrum was plainly visible, and I was pretty certain that a trace of the green carbon band was visible, but not absolutely certain. There was no doubt that the continuous spectrum was relatively much stronger than the gaseous carbon bands in this comet, than in any of the other comets I have observed, except in the case of Holmes' comet of 1892.

These comet photographs and many of the visual observations, were made with the 12-inch telescope and the large Brashear spectroscope mounted in a wooden case, using a 60° crown prism. This combination is very effective for photographing comet spectra, except that the clock and slow motions are unsatisfactory, and render the guiding very difficult. Further, this combination permitted me to make the observations without interfering with the regular spectroscopic work in the large dome. An extensive and expensive equipment is not necessary for the study of comet spectra, and the subject is seriously neglected. I desire especially to call attention to the importance of observing the spectra of periodic comets, both visually and photographically, at every opportunity. It is a good working hypothesis that the continuous spectrum is relatively stronger in periodic comets than in parabolic ones. As a comet approaches the Sun, its more volatile constituents are excited, electrically or otherwise, and are probably driven off permanently from the mass of the comet. For a parabolic comet this effect would be temporary, while for a periodic comet it would go on constantly, under the Sun's influence.; in which case it would seem that the bright-line spectrum of a periodic comet should gradually become less prominent. This view is supported by the observed spectra of Comet III, 1892 (Holmes) and Comet 1889–96 (Brooks-Javelle), and possibly by the meagerness of carbon in meteorites.

The four comet spectra which I have thus far been able to photograph, viz.,

1893 II (Rordame),
1894 II (Gale),
1895 IV (Perrine),
1896 I (Perrine),

have been identical so far as the different intensities of the four permitted comparison. All were parabolic comets.

NOVA AURIGÆ.

Occasional observations for the magnitude of the new star of 1892 in Auriga have been made. No change in brightness has been recorded since 1892.

In Vol. I., No. 1, of this JOURNAL I called attention to the remarkable changes going on in this star's spectrum. It was shown that the bright lines λ4360 and λ5750 which were very bright in August 1892 had become very faint in 1894. No photographs have been secured since November 1894, but visual observations show that the change in the line λ5750 has been progressive. The observed intensities of six of the principal bright lines have been as follows:

	$H\gamma$	λ4360	$H\beta$	λ4960	λ5010	λ5750
1892 August and September......	0.1	0.8	1	3	10	1
1894 May 8....................	0.1	0.3	1	3	10	0.4
1894 September 7..............	0.1	0.2	1	3	10	0.4
1894 November 28	0.1	0.1	1	3	10	0.3
1896 August 15................	—	—	1	3	10	0.1
1896 October 6................	—	—	1	3	10	0.1

At the date of the last observation the line λ5750 was difficult to see at all.

It is especially significant that the lines $\lambda 4360$ and $\lambda 5750$ should be the ones to change. The first measures of the spectrum in August 1892 showed unmistakably that it was the spectrum of a nebula. At first, however, the lines $\lambda 4360$ and $\lambda 5750$ did not seem to exist in the old nebulæ. But photographs of their spectra at once showed the line $\lambda 4360$ in five well-known nebulæ, and visual observations showed the line $\lambda 5750$ in three nebulæ. These lines were strong in the *Nova*, but relatively faint in the old nebulæ. They have now become relatively faint, in fact practically invisible, in the *Nova*. The spectrum of the new star has lost its anomalies: it is now of the ordinary type of nebular spectrum, save that the lines remain broad, as they have always been described.

As my apparatus has been arranged, it has not been convenient to re-measure the wave-lengths of the principal nebular lines since November 1894. The last few measures secured were made with a dense 60° flint prism and magnifying power 26—a combination much preferable to the grating and low power employed in the earlier measures.

While the spectroscopic observations of *Nova Aurigæ* show it to be *truly nebular*, there has been a question as to whether the nebulosity is *actually visible* in the focal image of a telescope.

When the reappearance of the *Nova* was observed on August 17, 1892 by Messrs. Holden, Schæberle and Campbell, "all the observers agreed that its appearance was different from that of other stars of the same magnitude."[1] Later Professor Barnard announced[2] that the object was "really a small bright nebula with a 10th magnitude nucleus. . . . . With the micrometer the nebulosity was found to be 3″ in diameter—a fainter nebulosity still surrounded this and was perhaps $\frac{1}{2}'$ in diameter."

Mr. Newall suggested[3] that the nebulous appearance was not real, but was due to the chromatic aberration of the object-glass, and that the image was truly stellar. This suggestion was

[1] *A. and A.*, **11**, 715.

[2] *A. and A.*, **11**, 751.

[3] *Nature*, **46**, 489.

repeated and carefully elaborated by Professor Vogel.[1] Dr. Huggins,[2] observing with a reflecting telescope, which is free from chromatic aberration, saw the image as a stellar point.

The focal image of the *Nova* in the 36-inch telescope certainly looked substantially as Professor Barnard described it.[3] But further consideration of the problem, together with actual experiments on the *Nova* and on the Wolf-Rayet star $+30°3639$,[4] soon convinced me that the 36-inch telescope, with its strong chromatic aberration, was not suitable for deciding this question definitely. For if any one of the numerous monochromatic images were brought into focus, all the others would be out of focus, and would combine to form a halo surrounding the central image. The yellow image at $\lambda 5750$, so long as it remained bright, augmented the difficulty.

I therefore determined to estimate the diameter of the *Nova* by observing the width of its spectrum. Observations for that purpose were made in the fall of 1893 and of 1894. The rather coarse micrometer wire was placed lengthwise of the spectrum, and its width was such as just to occult the principal nebular line when the atmospheric conditions were fair. From the known width of the wire and the proportions of the spectroscope and telescope, the angular width of the wire was computed to be $1\frac{1}{2}$ seconds of arc. On none of the nights utilized was the seeing perfect; but I attempted to eliminate the effect of imperfect seeing by observing, in the same manner, the continuous spectrum of a star so selected that its spectrum at $\lambda 5010$ and the principal nebular line would be of about equal intensities. In every case the two spectra were practically of the same width, thereby indicating that *the focal image of Nova Aurigæ is stellar.* At the same time it must not be forgotten that *Nova Aurigæ* is a true nebula: the spectroscopic evidence is indisputable.

[1] *Über den neuen Stern im Fuhrmann*, Berlin, 1893.

[2] *A. and A.*, **13**, 314–315.

[3] *A. and A.*, **12**, 419.

[4] This star has a hydrogen atmosphere, 5″ in diameter. *A. and A.*, **13**, 461.

The publication of these observations of the *Nova* has been unduly delayed—at first from a desire to repeat them on a first-class night, and later by the hope that the 36-inch Crossley reflector would be available for repeating them. As soon as the reflector is available I shall endeavor to get its testimony on this interesting question.

Lick Observatory,
University of California,
March 3, 1897.