THE FIRST DESLANDRES' GROUP OF THE POSITIVE BAND SPECTRUM OF NITROGEN, UNDER HIGH DISPERSION; A THESIS; PP.51-88 (NOT COMPLETE)

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The First Deslandres' Group of the Positive Band Spectrum of Nitrogen, under High Dispersion

A THESIS
SUBMITTED FOR THE DEGREE OF DOCTOR
OF PHILOSOPHY

BY

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bands have previously been made to λ 9100. The results seem to show that the spectrum consists of a series of band groups, each of which is most intense at the center, and diminishes in intensity toward either side. Kayser's *Handbuch*[1] gives only three groups, which he calls *a*, *b*, and *c*. Other groups of longer wave-length have since been found, and it appears now that there are six groups in all, which will be designated *a* to *f* respectively.

Group *a* 1.06 μ (?)
Group *b* 9101 (?) to 7887
Group *c* 7887 to 7059
Group *d* 7059 to 6185 (Kayser's *a* group)
Group *e* 6186 to 5485 (Kayser's *b* group)
Group *f* 5632 to 5126 (Kayser's *c* group)

Group *f* is quite different from the others. It has two intensity maxima, one at λ 5200 and the other at λ 5475. This would indicate two groups, but as the spacing is the same in both, it has been customary to classify them together. This group also overlaps considerably on group *e*.

The author obtained, besides the exposures on the large grating, one on a Hilger constant deviation spectroscope, extending to λ 7650. From this point to λ 9100 we have only the measurements of Croze.[2] Coblentz,[3] in connection with other infra-red work, has recorded positions of maximum intensity at 0.546, 0.667, 0.75, 0.90, and 1.06 μ. These are very evidently the approximate positions of maximum intensity in the several band groups. The reading at 1.06 μ points to the existence at this point of another group, which we have called group *a*.

In making this investigation the author had two objects in view: (1) to determine whether or not the bands in any one group were identical; (2) to determine, in case there were any similarities, whether corresponding lines in successive bands would fit into a Deslandres' series or other arithmetical relation.

The results of the study made thus far indicate that out of the 250 or more lines composing each band, at least 50 of the strongest are related to corresponding lines in other bands, and that the relationship is approximately that expressed by Deslandres' Law:

$$v=a+b(m+c)^2$$

[1] *Handbuch der Spectroscopie*, 5, 828.

[2] *Comptes rendus*, 150, 860, 1910.

[3] *Physical Review*, 22, 1, 1906.

where a, b, and c are constants, and m takes successive integral values.

EXPERIMENTAL ARRANGEMENTS

Atmospheric nitrogen, free from oxygen, carbon dioxide, and water-vapor, was used as a source. Hence the inert gases of the atmosphere were present, but the only lines due to them which have thus far been noted are a few of the stronger argon lines of the red spectrum. There is no trace of helium λ 5876. Traces of mercury diffused into the spectrum tube from the pressure gauge, but only the three strong lines at λ 5790, λ 5769, and λ 5461 appear, the last enormously overexposed.

The nitrogen was electrically excited in a Goetze "Type C" spectrum tube. The emission from the capillary of such a tube, in a "head-on" direction, appears to be the most intense, per unit cross-section, now obtainable. The electrical excitation was furnished by the secondary of a large induction coil, the primary being run on 110 volts A.C., 1.5 amperes. The nitrogen was introduced at about 5 mm pressure and used until the pressure fell to about 1 mm, low enough to cause a slight diminution of the radiation. Refilling of the tube was necessary only once in 24 to 36 hours.

The tube was placed accurately "head-on" to the slit of the grating, 60 cm away. A double convex lens of 15 cm focus produced on the slit a sharp image of the end of the capillary, somewhat more than 1 mm in diameter. This usual arrangement was now varied by introducing, at a distance of 12 cm from the slit, a double concave cylindric lens of 12 cm focus, placed with its axis horizontal. This caused the circular image on the slit to be drawn out into a vertical line some 2 cm in length. The use of such a cylindric lens in spectrum work has been advocated by Humphreys,[1] but I know of no definite statement of the advantages and disadvantages incident to its use.

The action of the cylindric lens is greatly to reduce the vertical aperture of the cone of rays proceeding from the slit. With the particular lenses used, it is possible, with a source of light less than approximately 2 mm in diameter, to reduce the vertical aperture, at the grating, to less than the length of the grating rulings. Thus

[1] *Astrophysical Journal*, 18, 324, 1903.

the cross-section of the cone of light at the grating, instead of being a 75-cm circle, is reduced (roughly) to an ellipse of 75 cm horizontal diameter, but with a vertical diameter of 5 cm or less. The gain in intensity of the middle point of the astigmatic image at the camera is theoretically $\frac{75\text{ cm}}{5\text{ cm}}=15$. The actual increase, determined experimentally, was thirteen fold.

If now the source is made 4 mm in diameter, instead of 2, the amount of light actually striking the grating, using the cylindric lens, is scarcely increased at all. But with the ordinary arrangement, the amount would practically be doubled. Hence the advantage of the cylindric lens is proportionally decreased. For sources more than 2 cm in diameter, there is no appreciable advantage in using a cylindric lens.

The chief disadvantage attendant upon its use is the necessity of accurate adjustment. The centers of the tube, convex lens, concave lens, and slit should all lie accurately in the horizontal plane formed by the center of the grating and of the camera. With this condition fulfilled, and the cone of light falling symmetrically upon the grating, a raising or lowering of the cylindric lens of even one-tenth of a millimeter is sufficient to throw an appreciable portion of the light entirely below or above the rulings of the grating.

Because of the excess of radiation in a "head-on" direction, the illumination of the grating is far from uniform; but this is true even when the cylindric lens is not used. Such a non-uniformity is liable, however, to cause a shift of the lines of the comparison spectrum relative to those under investigation. The actual shifts found in many cases, between the iron and nitrogen lines, are believed to be due primarily to this cause.

As a comparison source I used an iron arc of the Pfund[1] type, run on 200 volts, 5 amperes, with iron and carbon electrodes. It worked in a very satisfactory manner. The exposures were made in the second order, and both the second-order and coincident third-order international iron normals were used, the measurements in the ultra-violet being those of Buisson and Fabry,[2] not yet officially adopted as standards.

No relative shift of orders could be detected on those plates where both the second- and third-order normals were present.

[1] *Astrophysical Journal*, 27, 296, 1908. [2] *Ibid.*, 28, 169, 1908.

Whenever two normals fell near together and were both of suitable intensity for an accurate setting, the agreement was perfect. When one or both lines were overexposed the disagreement might be anything from 0.007 A down. This was taken to indicate that the secondary international normals, when overexposed, do not necessarily broaden symmetrically. The much greater uniformity in intensity of the normals between λ 3500 and λ 4500 thus makes them preferable for use, and this fact, coupled with the great faintness of the normals from λ 5900 into the red, caused the author to use only the coincident third-order normals in the region λ 5900 to λ 6800.

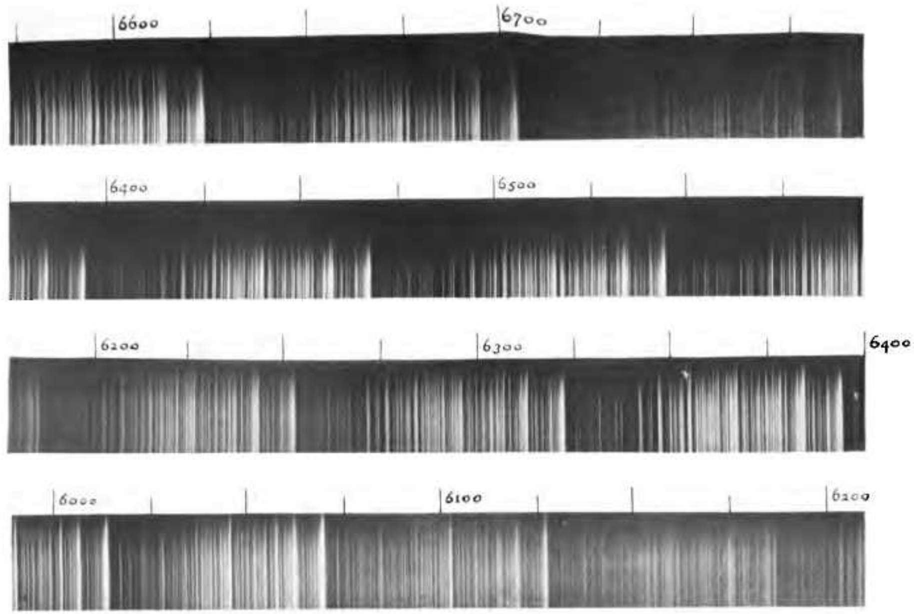
In order to eliminate the exceedingly strong violet bands of nitrogen, an 8 per cent solution of potassium chromate 5 mm thick was employed. The absorption of this solution sets in at about λ 5200 and this accounts for the rapid decrease in intensity below this point. (See Plate III.) Although the head of the λ 3576 band is a thousand times as intense, photographically, as that of any band under investigation, no trace of it appears on the exposures. Fluorescein was tried as an absorbent and found quite ineffective.

For the exposures from λ 5000 to λ 5900 the Cramer Instantaneous Isochromatic plates were employed, while from λ 5800 to λ 6900 both Cramer "Spectrum" and Wratten & Wainwright "A" Panchromatic were used. For the one exposure on the Hilger spectroscope, from λ 6800 to λ 7700, I used a Wratten & Wainwright "B" Panchromatic plate.

The strongest portion of the spectrum, from the photographic standpoint, is that from λ 5700 to λ 5800. The λ 5804 band is fully three times as intense as that at λ 6623, the only one which von der Helm appears to have obtained sufficiently intense for measurement. The region from λ 5500 to λ 5900 was accordingly photographed first, using $12 \times 1\frac{1}{4}$ inch plates, and the usual Rowland type of comparison shutter. All other exposures were made with $18 \times 2\frac{1}{2}$ inch plates, using a comparison shutter, mounted independent of the camera.

In making exposures several days in length, the greatest problem is a proper control of temperature. Fortunately for the author, the large grating of the University of Wisconsin is mounted inside a double-walled room, built in turn entirely inside an ordinary room.

PLATE II



Positive Band Spectrum of Nitrogen