THE EXCITATION OF THE AURORA GREEN LINE IN ACTIVE NITROGEN

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ABSTRACT

The aurora green line has been excited in the nitrogen afterglow when oxygen was present in the discharge in which the active nitrogen was produced and observed. The interpretation of this phenomenon is based on the recent hypothesis as to the nature of active nitrogen as presented by Kaplan and Cario.

LAST spring the writer[1] reported the excitation of the aurora green line in active nitrogen. In view of the developments since then in the study of active nitrogen it is now thought that a more detailed discussion of the above experiment would be of some value. It is the purpose of this paper therefore to discuss the excitation of the green oxygen line in active nitrogen.

The apparatus used was very simple. The discharge tube was a 500 cc Pyrex bulb through which a condensed discharge from a 1-kw., 15000-volt Thordarsen transformer was passed. The gas was pumped through the discharge tube continuously at a pressure of about 0.5 mm. The spectrum of the afterglow was photographed on a small Hilger spectrograph for the visible and the glow in the discharge tube was photographed by using a rotating sectored disk which was adjusted so as to allow only the light of the afterglow itself to fall on the slit of the spectrograph. Eastman Astronomical Green plates were used. The dispersion was necessarily very small and for that reason the accuracy of the wave-length determination was only about

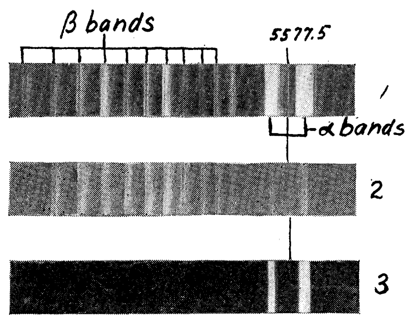

Fig. 1. (1) Afterglow in 4% O_2, 96%N_2, exposure, 12 hours; (2) afterglow in 20% O_2, 80% N_2, exposure 12 hours; (3) afterglow in commercial N_2, exposure, 12 hours.

0.1A. The wave-length found for the green line was 5577.5 instead of the very accurate value of 5577.35A found by Babcock.[2] The experimental conditions under which the line appeared however are such as clearly to show that

[1] Kaplan, Nature **121,** 711 (1928).
[2] Babcock, Astrophys. J. **57,** 209 (1923).

the line was caused by the presence of the oxygen and it is obvious therefore that the conclusion as to its identity is correct.

The three spectra show clearly the conditions under which the line was excited. In spectrum 1 the percentage of oxygen was about 3 or 4 percent and the β bands of NO are fairly well developed. The green line is more intense on this plate than some of the β bands and also much more intense than the weaker α bands. In spectrum 2 the percentage of oxygen is about 20 and the green line is weak, much weaker in fact than most of the β bands. The α bands are also extremely weak. In spectrum 3 the α bands are very strong, the green line is extremely faint and the β bands are very faint. The percentage of oxygen in this case was very small, commercial nitrogen having been used.

It is possible from these three spectra and from evidence as to the nature of active nitrogen, to draw a clear cut interpretation as to the method by which the excitation of the green line took place.

According to the recent views of Cario and the author,[3] the spectrum of active nitrogen can best be explained if it is assumed that in addition to normal atoms there are present metastable molecules in the A level and metastable atoms in the ^2D and ^2P levels. The energy of the metastable atoms in the ^2P state is 3.56 volts and that in the ^2D level is 2.37 volts.[4] In order that the α bands be strongly developed in the afterglow it is essential that these metastable atoms be present in the glow in great numbers. On spectrum 1, on which the α-bands are very strong and the green line also strong, these conditions are fulfilled. There are present metastable atoms and undoubtedly atomic oxygen that has been formed in the discharge itself. Collisions between metastable atoms of nitrogen in the ^2P state and normal oxygen atoms give rise to the excitation of the green line. That the energy of 3.56 volts is more than enough to do this is shown in the discussion of the aurora spectrum by the author.[5] In this it is pointed out that the difference between $^1S_0$ and ^3P cannot be greater than 3.4 volts. The ^2D metastable atoms can raise the atom from the $^1D_2$ state to the $^1S_0$ state, which is now thought to be the upper level of the green line transition.[6] It is interesting here to point out that the green line can be observed with appreciable intensity in a discharge only when argon is mixed with the oxygen. The explanation of this can readily lie as Cario suggested,[7] in the frequency of transitions in argon which lie between 2.9 and 3.1 volts. From the discussion of the auroral spectrum it is possible to show that the difference $^1S_0 - {}^3P$ is roughly about equal to 3.0 volts and this indicates that argon is effective in exciting atomic oxygen by collisions of the second kind in which 2.9 to 3.1 volt transfers are effective. On spectrum 2, the green line is only feebly developed in spite of the presence of 20 percent oxygen. At the same time the α-bands were very weak showing

[3] Cario and Kaplan, Nature **121,** 906 (1928).
[4] Compton and Boyce, Phys. Rev. **33,** 145 (1928).
[5] Kaplan, Proc. Nat. Acad. Sci., in press.
[6] McLennan, McLeod and Ruedy, Phil. Mag. **6,** 558 (1928).
[7] Cario, Journal Franklin Inst. **205,** 575 (1928).

that the number of metastable nitrogen atoms was very small and consequently that the green line excitation could be only feeble, in spite of the presence of considerable oxygen. This agrees with the interpretation suggested above.

In spectrum 3 there is almost no excitation of the green line because of the presence of only a very small amount of oxygen. This plate simply gives added proof that the line is due to oxygen. It is significant that the green line was excited only when the afterglow was photographed in the discharge tube itself. Cario was unable in only a few attempts to observe the line in active nitrogen that had diffused away from the discharge in which it had been formed. The failure to observe the green line away from the discharge can readily be explained if it is remembered that atomic oxygen combines very readily with molecular oxygen to form ozone. The absence of the green line outside of the discharge can be ascribed to the absence of atomic oxygen outside of the discharge itself. This indicates that the collisions which are essential in the excitation of the green line are probably the ones discussed here. There is enough energy available in metastable molecules of nitrogen and in three body collisions with atoms or in collisions with excited molecules to dissociate the oxygen molecule into atoms. Apparently this process does not occur readily since it is well known that the mixing of oxygen with active nitrogen results in the formation of nitric oxide and the excitation of NO bands. A detailed discussion of this point however requires more experimental facts and will not be attempted here. The experimental work discussed in this paper was done while the author was a National Research Fellow at Princeton University.

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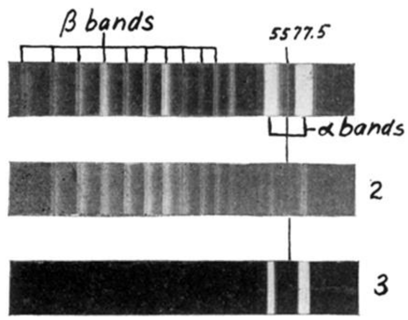

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