For a hydrogen-like atom of nuclear charge Z the potential energy is $V = -eZ/r$ and $\frac{\partial V}{\partial z} = eZ \cos \theta / r^2$. When the wave equation is separated in spherical polar coördinates so that the unnormalized wave functions are given by

$$\psi_{n,l,m}(r,\theta,\phi) = x(r) e^{im\phi} P_l^m(\cos \theta)$$

where

$$x(r) = \left(\frac{2r}{a_0 n}\right)^l \cdot e^{-r/a_0 n} L_{l+n}^{2l+1}\left(\frac{2r}{a_0 n}\right)$$

and where $a_0 = h^2/4\pi^2 meZ$, we get from (7) and results assembled by Kupper*

$$A_3(n,l,m; n',l',m') = -\frac{eZ}{m}\left(\frac{l^2 - m^2}{4l^2 - 1}\right)^{1/2} \cdot \frac{1}{N_r} \int_0^\infty x_n(r) x_{n'}(r) dr \quad (13)$$

where N_r is a normalizing factor. The factor of this expression depending on n,n' differs from that which would be obtained by the Heisenberg amplitude rule. The latter rule is only strictly accurate when applied to an harmonic oscillator.

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* *Ann. Physik*, **86**, 511, 1928.

THE AURORA RED LINE

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Recently[1] the author reported some experiments concerning the excitation of the aurora green line when oxygen was mixed with active nitrogen. In that report it was mentioned that a red line having a wave-length of 6654.8 A.U. was also excited and its agreement with an unclassified oxygen line prompted the suggestion that the line 6654.8 may be an oxygen line. One would therefore be justified in concluding that this line should be observed in the light of the night sky and in the Aurora Borealis.

Following a suggestion by Dr. G. Cario, the author reëxamined the plates on which the red line was photographed and the conclusion has been reached that this "line" is in reality a band belonging to the first positive group of nitrogen. In the following discussion the reasons for this conclusion will be presented.

While studying the conditions under which the green line was excited it was noted that the red line diminished in intensity very little, as the amount of oxygen was reduced. Because of this it was doubtful whether or not this line should be assigned to oxygen. It was difficult, however, to call it an α-band since each of the other bands in the afterglow consisted of four heads, whereas this would have been an α-band with a single head. A photograph of the discharge tube spectrum in this region showed only the usual four-headed bands, and did not show this line at all. Consequently, it seemed reasonable at the time to assign the line to oxygen, especially in view of the remarkable agreement in wave-length between it and the unclassified line of oxygen at 6654.8 A.U.

Using the data presented by A. H. Poetker[2] it is possible to predict the positions of α-bands corresponding to transitions that are normally very weak in the discharge tube. In active nitrogen, many of the excited molecules of nitrogen find themselves in the B_{10}, B_{11} and B_{12} states. The strong afterglow bands correspond to B-A transitions in which the vibrational quantum numbers change by -3, -4, -5 and -6. Because of the prevalence of these excited states the transitions B_{12}-A_{10} and B_{11}-A_9 might well be expected to appear in the afterglow. Therefore, the first heads of these bands were calculated and predicted to fall at 6670 Å and 6764 Å, respectively. From these predicted positions of the first heads, still using data presented by Poetker, it was possible to predict the second heads of these bands and these were found to be at 6754 Å and 6657 Å. On reëxamining the plates it was found that there was a single head at about 6750 Å superposed on a background of other normal first positive bands. This value, taken in conjunction with the position of the red "line," justifies the conclusion that these two single heads must correspond to the second heads of the bands arising from the B_{12}-A_{10} and the B_{11}-A_9 transitions. The meaning of the curtailed development of these bands as contrasted with the normal development of the other bands is not understood at present and this will be studied at the first opportunity. Because of the assignment of the "line" at 6654.8 to the α-group one can conclude definitely that the green line is the only line of oxygen that is excited by active nitrogen in the visible. This agrees with the bulk of experimental evidence according to which the green line is the only oxygen line that has been found in the Aurora Borealis and in the light of the night sky.

Recently McLennan, McLeod and Ruedy[3] concluded from the newly determined Zeemann effect of the green line, that it arises in a transition between the two low-lying metastable states ${}^1S_0$-${}^1D_2$. Assuming this as the proper classification of the green line, one can give a lower limit to the wave-length of transitions between these two metastable states and the normal triplet levels ${}^3P_{0,1,2}$. This is done by simply remembering Hopfield's discovery that the energy difference between the two far ultraviolet singlet lines of oxygen at about 1217 and 999 A.U., respectively, is exactly the energy corresponding to the green line. This means that the two lines correspond to transitions between a common upper level and the two metastable states, $^1S_0$ and $^1D_2$. This common upper level must therefore lie 12.34 volts above the $^1D_2$ level. Since the ionization potential of oxygen is 13.56 volts the transition $^1D_2$-$^3P_{0,1,2}$ can be no greater than $13.56 - 12.34 = 1.22$ volts. Consequently, lines corresponding to those transitions must lie above 1μ. These are the only transitions that can result in a red auroral line and one is therefore not surprised at the non-observance of a red auroral line in the aurora or in the night sky.

Similarly, the transitions $^1S_0$-$^3P_{0,1,2}$ must lie at wave-lengths higher than 3575 A.U. and no such transitions have been observed in the Aurora, in the night sky or in laboratory experiments. This is not surprising because of the great improbability of intercombinations. It therefore seems probable that the green line is the only oxygen line in the auroral spectrum.

[1] *Nature*, **121**, p. 711, 1928.

[2] Poetker, *Phys. Rev.*, **30**, p. 812, 1927.

[3] McLennan, McLeod and Ruedy, *Phil. Mag.*, **6**, p. 558, 1928.

A VISUAL METHOD OF OBSERVING THE INFLUENCE OF ATMOSPHERIC CONDITIONS ON RADIO RECEPTION[1]

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There seems to be little doubt that radio signals may pass from one station to another by at least two different paths. The "ground wave" presumably follows the surface of the earth in much the same way that shorter waves are known to follow a wire. The "sky wave" starts obliquely upward from the sending station and reaches the observer after being bent or reflected by the Kennelly-Heaviside layer of highly ionized air. Both are subject to absorption due to the conductivity of the air, and the sky wave may have its plane of polarization rotated, or may suffer a sort of magnetic double refraction, because of the earth's magnetic field.

Changes in the ionization of the air and the height of the Heaviside layer will thus lead to changes in the amplitude, phase and polarization of the two waves, so that when both reach the receiving station together very complicated results are to be expected. That the results are in fact complicated and confusing is evidenced by the fading observed in broadcast reception and by the erratic changes in the apparent direction