A shift in the absorption limit with charge-carrier density should also be observable at sufficiently high charge-carrier densities in other semiconductors. However, the absorption by free charge carriers at the high densities needed would, in general, mask the intrinsic absorption limit and thereby prevent the effect from being observed.

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Origin of the Emission of the Oxygen Green Line in the Airglow*

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IT is well known that the airglow emission of the oxygen green line at λ5577A cannot be attributed to the ordinary chemical sources if the altitude of the airglow layer is greater than that of the E layer. Furthermore, ionic recombinations involving negative ions in Region F are not sufficient to lead to an airglow emission. Finally, while the hypothesis of incoming particles exciting this emission has been put forward, it remains vague and cannot account for the variations which are observed.

According to the observational data,[1] the height of the emission layer is of the order of 250±50 km, and the maximum of intensity occurs at local midnight ±2.5 hours. The observed annual variation shows several maxima and indicates, therefore, a quite complex variation. Finally, the isophotal plots of the intensity changes of various parts of the sky suggest the presence of a definitive emission pattern in the high atmosphere.

In order to explain such an emission, recourse must be made to results obtained by Nicolet and Mange[2] on the vertical distribution of molecular oxygen. The charge-exchange process considered by Bates and Massey[3] can be applied in the following form in the F_2 layer:

$$O^+ + O_2 \rightarrow O + O_2^+. \quad (1)$$

The reaction (1) is followed by

$$O_2^+ + e \rightarrow O' + O'', \quad (2)$$

namely, a dissociative recombination process first discussed by Bates and Massey[3] and calculated by Bates.[4] Dissociative recombination of O_2^+ is a powerful excitation mechanism for the green line in the airglow.

Because molecular and atomic oxygen are in diffusive equilibrium at 200 km, we can assume the following vertical distributions:

$$n(O) = n_0(O) \exp[-(1+\beta)\zeta], \quad (3)$$

and

$$n(O_2) = n_0(O_2) \exp[-(2+\beta)\zeta], \quad (4)$$

in which $n_0(O)$ and $n_0(O_2)$ denote the concentrations at the reduced[5] height $\zeta=0$, $n(O)$ and $n(O_2)$ are the concentrations at height ζ, and β is the scale height gradient of atomic oxygen.

Numerical values[2] show that O_2 is still an important constituent in Region F; of the order of 5×10^7 cm^{-3} at 200 km, 5×10^6 at 250 km, 5×10^5 at 300 km and 10^5 at 350 km. According to ionospheric observations,[6] an average peak of the night-time F_2 layer may be considered at heights of the order of 300–350 km. The vertical distribution of the electron concentration n_e can be represented[5] by the following formula:

$$n_e = (n_e)_0 \exp\{\tfrac{1}{2}(1+\beta)[1-\zeta(1-\eta)-e^{-\zeta}]\}, \quad (5)$$

in which η denotes a parameter giving the form of the particular distribution. If $\eta=0$, the conventional form is obtained in which the total electron content of the layer is three times the content below the peak. If $\eta=1/(1+\beta)$, the recombination coefficient can be proportional to the pressure and the total electron content is six times the content below the peak. It is known that these extreme forms may represent the behavior of the F_2 layer[7] in winter and summer.

Ionization potentials of O and O_2 being 13.60 ev[8] and 12.04 ev,[9] respectively, O_2^+ obtained by (1) is in the electronic state $(^2\Pi_g)$ from $v=0$ to $v=6$ at most. The dissociation potential of oxygen being 5.11 ev,[10] process (2) *a priori* leads to three possibilities as far as the energy balance is concerned:

$$O_2^+ + e \rightarrow 2O(^1S), \text{ or } O(^1S) + O(^1D), \text{ or } O(^1S) + O(^3P).$$

From this, one concludes that the emission of the green line might be produced by this means. If the complete use of the energy may yield two excited atoms ^1S, it must be pointed out that the rate of the emission processes depends on the repulsion curves of states leading to dissociation products ^1S, ^1D, and ^3P.

At F_2 layer heights, $n(O^+) > n(O_2^+)$, so that, thanks to (3), (4), and (5), we may deduce the following vertical distribution of the green line emission:

$$I_{5577} \propto \exp\left\{(1+\beta)\left[1-\zeta\left(\frac{2\beta+3}{1+\beta}-\eta\right)-e^{-\zeta}\right]\right\}. \quad (6)$$

The gradient of the scale height being $\beta=0.3$, the peak of the emission corresponds to a value of ζ varying from -1 to -2 below the peak of the electron concentration (300–350 km), i.e., an altitude of 250 km.

It follows from these calculations that an airglow emission in Region F is possible. A complete account of this work will be published elsewhere. This will show the interdependence of the emission of the green line and of the properties of an ionospheric layer in which molecular oxygen ions play an important part on account of vertical transport by diffusion.[11]

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Threshold Energies for Sputtering and the Sound Velocity in Metals

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THE author has recently[1] described experiments which show that the minimum threshold energy for sputtering is a function of the angle of incidence of the bombarding ions. Previous attempts to measure threshold energies failed to give reliable results because they were made either in the glow discharge or with wires which are small compared to the ion sheath thickness;[2,3] in both cases, however, the angle of incidence is undetermined.

With a low gas pressure (1 micron) and a large sputtering electrode immersed in a plasma of high density (10^{11}–10^{12} per cm^3), it is possible to avoid collisions of the ions within the ion sheath and to approach the plane case with predominantly