Altitude Effects in the Red Part of the Auroral Spectrum and the Two Types of Red Auroras

IN a previous note in NATURE[1], I described observations made at Oslo of an auroral display which showed red upper limits, while the lower part had the ordinary greenish-yellow colour. Spectroscopic observations gave an enormous enhancement of the red oxygen line 6300 with increasing height. In a later paper[2], I described quantitative measurements of spectrograms corresponding to auroras of ordinary colour, which also gave a considerable enhancement of the red line 6300 with increasing altitude. It became a matter of importance to make further measurements in order to see if the altitude effect on the red line was a general occurrence.

During auroral displays which were observed at Oslo on the two nights of October 11–13, 1937, I obtained on panchromatic plates four pairs of spectrograms. For each pair the spectrograms were taken as quickly as possible in succession, one from the lower, the second from the upper limit of the auroral streamers. Photometer curves of the spectrograms covering the red part and the green line 5577 are shown in the accompanying illustration. The first pair, I, was taken on the evening of October 11, the other three pairs II, III, IV during the following night.

Although the relative intensity of the red line is very different for different pairs, we find that *for each pair the relative intensity of the red line increases as we pass upwards from the lower to the upper limit.* By means of an intensity scale taken by means of a light source of known intensity distribution, we found the following intensities (I_r) of the red line relative to the green one :

Pair	I_r (upper)	I_r (lower)	$\frac{I_r \text{ (upper)}}{I_r \text{ (lower)}}$
I	2·74	1·15	2·38
II	0·82	0·60	1·37
III	0·75	0·36	2·08
IV	1·07	0·34	3·15

Mean, 2·25

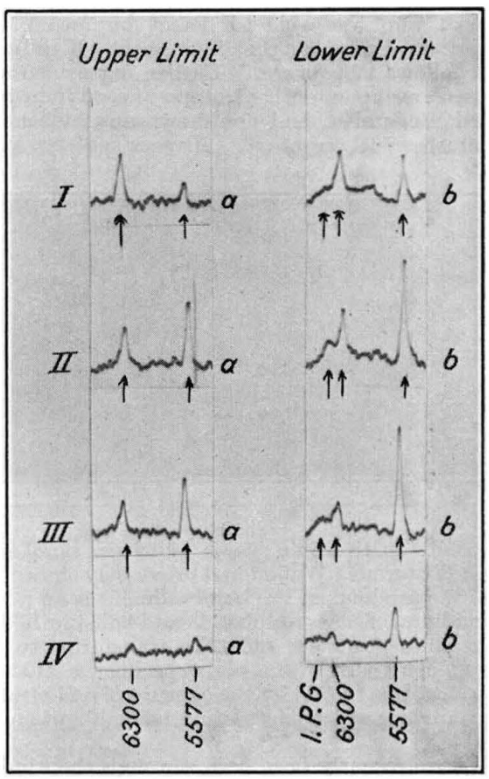
On an average, the relative intensity of the red line at the upper limit is 2·25 times that at the lower.

The numbers also confirm the result previously described[2] that the red line 6300 may obtain an intensity considerably greater than that of the green line, a result which shows that the $^1D_2$-state is excited by a certain process, which acts independently of that which excites the $^1S_0$-state, and which results in the emission of the green line.

The photometer curves for the lower limit all show distinctly the bands of the first positive group, while these bands are absent on all the curves corresponding to the upper limits showing the existence of a pronounced altitude effect of the first positive group, and in such a way that its intensity relative to that of the green line *increases as we pass downwards in the auroral region.* The altitude effects of the red line 6300 and of the first positive group have an interesting bearing on the two types of red auroras called *A* and *B*.

As I have shown, the red colour of type *A* is due to the enhancement of the red line 6300, which is particularly prominent during sunspot maxima and when the atmosphere is exposed to sunlight.[3] *The altitude effect of this line means that this type of red aurora has a tendency to be more intensively red towards the upper limits of the streamers.* The enhancement is shown to be due to an excitation process which brings the O-atom directly to the $^1D_2$-state, and this process is associated with some component of the atmosphere formed by the action of short-wave radiation from the sun. This component is probably ozone, and the $^1D_2$-state is excited through collisions between ozone molecules and nitrogen molecules in the metastable $A(^3\Sigma)$-state (cf. ref. 2).

Type *B* is characterized by an intense red colour along the *lower border* and was shown to be due to the enhancement of the first positive group, which is particularly pronounced when the aurora reaches a very low altitude. The results given in this note show that the enhancement is not restricted to regions near the lower limit, but *the first positive group shows a gradual enhancement as we pass from the upper limit downwards.*



Usually the electric rays do not reach so far down that the enhancement of the first positive group is sufficient to give the aurora a red lower border. A weak reddish lower border is fairly frequent, but auroral bands with an intense and fairly broad red lower border are very rare and *seem to be most frequent at times of sunspot minima*[4], showing that the electric rays obtain the greatest maximum energy at sunspot minima.

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[1] Vegard, L., NATURE, **138**, 930 (1936).
[2] Vegard, L., *Z. Phys.*, **106**, 108 (1937).
[3] Vegard and Tönsberg, NATURE, **137**, 778 (1936).
[4] Vegard, L., *Geophys. Pub.*, **10**, No. 4 (1933).