PHOTOMETRIC OBSERVATIONS OF 5577 Å AND 6300 Å AIRGLOW DURING THE I.G.Y.

By R. A. Duncan*

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Summary

Twenty-one months' observation of the airglow from near Sydney, Australia, shows that (*a*) aurorae are detected 10° above the southern horizon at 6300 Å whenever the magnetic disturbance index (K) reaches 5 but K must reach 7 before detection is certain at 5577 Å; (*b*) the 6300 Å zenith intensity increases rapidly with K once this equals or exceeds 4, but the 5577 Å zenith intensity is independent of magnetic disturbance; (*c*) the zenith intensity of 5577 Å tends to be a maximum at 03 hr local time; (*d*) the zenith intensity of 6300 Å drops rapidly from dusk till 01 hr and then rises till dawn.

I. Introduction

As part of the I.G.Y. programme a nightglow photometer, lent by the American National Bureau of Standards, has been operated at Camden, near Sydney (geographic lat. 34° S., geomagnetic lat. 42° S.), since March 1957.

The intensity of the green oxygen emission at 5577 Å was monitored on 280 clear nights from March 1957 till July 1958. After July 1958 attention was concentrated mainly on the red oxygen emission at 6300 Å. Sixty-six clear nights' observation of the red nightglow were obtained to the end of 1958.

In the present paper these observations are studied for dependence on magnetic and ionospheric parameters and for nocturnal behaviour. The results are compared with those of similar studies in the northern hemisphere.

II. The Instrument

The photometer has been described by St. Amand (1955). It has high spectral purity, successfully eliminating the continuous background even during bright moonlight. It scans the sky in a series of horizontal circles at successive zenith distances of 80, 75, 70, 60, 40, and 0°, a complete sky scan taking about four minutes, and usually being repeated each quarter hour.

The photometer sensitivity was calibrated by Roach (1958) against a portable standard photometer, thus permitting comparison with nightglow photometric observations in other parts of the world.

III. Photometric Observations of Auroras

Auroras show clearly on the photometric records as pronounced brightening to the south or as structures such as arcs and rays (Duncan 1959). Figure 1 shows the probability of detecting an auroral form, as a function of the magnetic

* Upper Atmosphere Section, C.S.I.R.O., Camden, N.S.W.

disturbance index (K). It will be seen that the red line is much more prone to auroral excitation than the green. Auroras are always detected at 6300 Å when the magnetic index K reaches 5 but K must reach 7 before we can be sure of detecting an aurora at 5577 Å. This accords with the common observation (e.g. Seaton 1956) that middle latitude auroras are predominantly red.

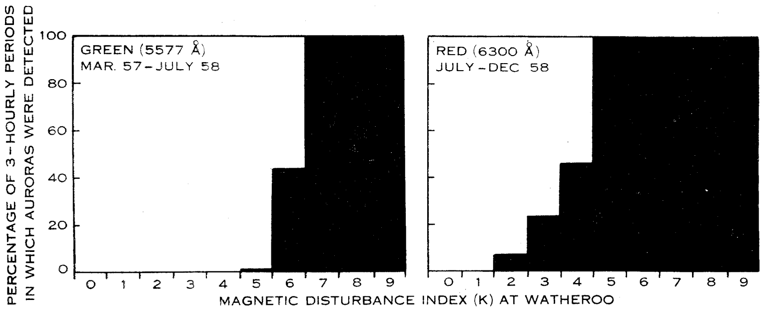

Fig. 1.—The percentage of 3-hourly observing periods during which auroral forms were detected by the photometer against the magnetic disturbance index (K) at Watheroo.

IV. Airglow and Magnetic Disturbance

It may be asked whether auroras make an appreciable contribution to the zenith airglow intensity. A study of the relation between airglow and the magnetic disturbance index K probably has some bearing on this problem.

It will be seen from Figure 2 that, except for the sporadic effect of a few great auroras, the zenith green airglow intensity is independent of the magnetic disturbance index K.

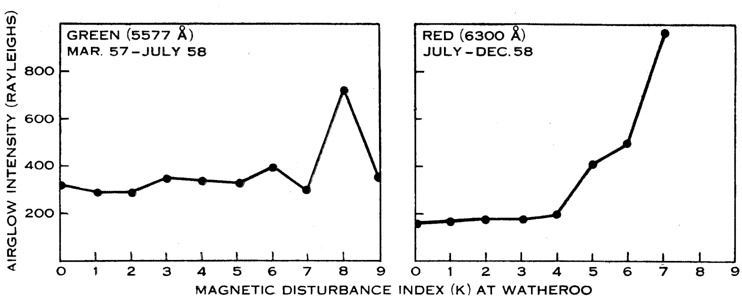

Fig. 2.—The mean zenith airglow intensity against the magnetic disturbance index (K) at Watheroo.

The zenith red airglow intensity, on the other hand, while independent of the magnetic disturbance index K so long as this is less than 4, increases rapidly with larger K. It would seem that the red airglow has a basic non-auroral level of about 175 rayleighs, plus a substantial auroral component on magnetically disturbed nights.

Recently, Roach (1960) has shown that, although the mean intensity at 5577 Å is not significantly increased, there is a tendency for sporadic high 5577 Å

TABLE 1
LOCAL TIMES OF MAXIMUM 5577 Å EMISSION

Station	Latitude	Time of Maximum	Observers
Haute Provence, France ..	44° N.	23·7	Barbier, Dufay, and Williams (1951)
Mt. Elbrus, Russia ..	43° N.	01·6	Rodionov, Pavlova, and Rdultoskava (1949)
Cactus Peak, U.S.A. ..	36° N.	00·2	Roach, Williams, and Pettit (1953)
Flagstaff, U.S.A.	35° N.	01·5	McLennon, McLeod, and Ireton (1928)
Camden, Australia ..	34° S.	03	Duncan
Sacramento Peak, U.S.A...	33° N.	23–01	Manring and Pettit (1958)
Poona, India	18° N.	Minimum 01	Karandikar (1934)

intensities to occur at times of high K-index. Camden data support this conclusion. McCaulley, Roach, and Matsushita (1960) have shown that the lack of correlation between 5577 intensities and magnetic disturbance index K is largely due to the imprecise nature of the K-index. They found a good correlation between 5577 intensities and the horizontal component of the geomagnetic field measured on a nearby magnetometer.

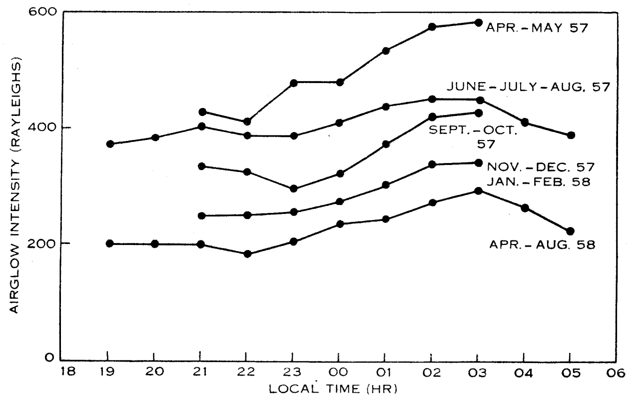

Fig. 3.—Mean nocturnal variation of the zenith green (5577 Å) airglow.

V. Nocturnal Variation of the Green (5577 Å) Airglow

The nocturnal variation of the zenith green airglow has been studied by a number of workers. Their results are summarized in Table 1. Observations at Camden confirm previous reports that the diurnal variation varies greatly from night to night. The mean nocturnal variations for each season, however, show a consistent pattern (Fig. 3). In winter a maximum is found at 03 hr. In summer observations run only from 21 to 03 hr, but within this time interval the nocturnal behaviour seems similar to that found in winter.

Observers at middle latitudes in the northern hemisphere (Table 1) have found maxima between 23 and 01 hr.

VI. Nocturnal Variation of the Red (6300 Å) Airglow

The zenith red (6300 Å) airglow shows a far more pronounced and consistent nocturnal variation than the green (Fig. 4). Earlier workers (Elvey and Farnsworth 1942 ; Barbier 1957*a*) have described a dusk and dawn enhancement of the red airglow, but as a transient effect superimposed upon, and easily distinguishable from, the " true " nightglow. It would appear from Figure 4 that the dawn and dusk enhancements are simply parts of a smooth nocturnal variation. If this variation were to be explained entirely in terms of resonance scattering of sunlight, the terrestrial atmosphere would need to be effective at heights as great as 2000 km, for the winter dawn increase is already apparent at 03 hr. The nocturnal variation (Fig. 4) is not symmetrical about midnight. It is about twice as bright at dusk as at dawn, and the lowest intensity occurs not at midnight

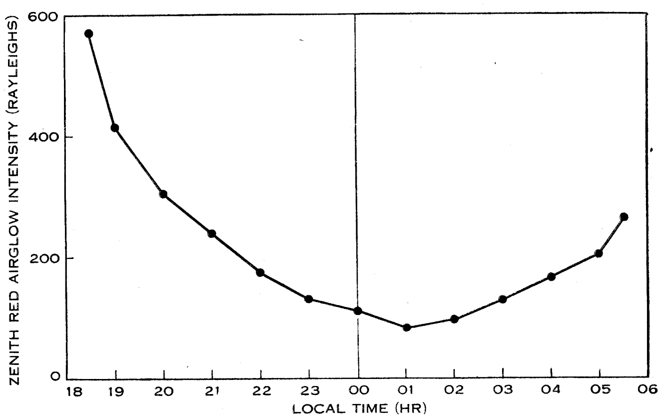

Fig. 4.—The nocturnal variation of the zenith red (6300 Å) airglow intensity. Mean for 20 nights during July and August 1958.

but at 01 hr. This suggests that, in addition to an airglow component dependent on the solar zenith angle, there is a component which decreases steadily from dusk to dawn. Possibly this is due to the dissipation (as airglow) of solar energy absorbed by the upper atmosphere during the day.

Bates and Massey (1946) have suggested that both the red airglow and the decay of the F_2 region could result from the reaction

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

In support of this Barbier (1957*b*) found, for the first half of the night, an empirical relation

$$I = (5 \cdot 83 \times 10^6)(f_0)^2 \exp\{(-h' - 200)/88\} \quad \ldots\ldots\ldots \quad (2)$$

between the red airglow intensity I and the ionospheric height h' and critical frequency f_0. A comparison of Camden ionosonde and airglow records gives no support to this finding. Certainly there is support of a kind in the fact that both the red airglow intensity I and f_0F_2 decrease during the first half of the night. However, the airglow intensity at a given hour varies by a factor of 2 or 3 from night to night and these fluctuations bear no direct relation to ionospheric parameters. Part of the variability is due to magnetic disturbance. As Figure 2 shows, the average red airglow intensity I increases with magnetic disturbance while, as is well known, magnetic storms cause f_0F_2 to decrease and $h'F_2$ to increase. These changes are in opposite directions to those required by equation (**2**).

Barbier also found that the second half of the night was characterized by an enhanced glow which appeared to the north and gradually spread over the entire sky. This phenomenon has never been seen to the south at Camden.

VII. Acknowledgments

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