LETTERS TO THE EDITOR

GEOPHYSICS

Atmospheric Blow-up at the Auroral Zone

ELSEWHERE^{1,2} I have examined joule heating of the upper atmosphere by those ionospheric electric currents which cause geomagnetic disturbance. Some further consequences were recently reported³. It is the purpose of the present communication to point out that in regions of the auroral ionosphere above about 150 km. altitude the scale height may increase 5- to 10-fold during geomagnetic disturbance. This would cause population of the exosphere to great heights with ionospheric gases and even loss of a portion of such gases to the interplanetary medium.

Joule heating in the auroral ionosphere is rapid. In the event of no loss of heat by conduction or convection it would cause the scale height at 160 km. altitude to double in a matter of seconds^{1,2}, whereas the electric currents responsible flow for periods of order 0.5 hr. Let us estimate the effect of convection and conduction on the process of increasing the scale height. Suppose an auroral electrojet is 100 km. wide in latitude cross-section. Winds of the order of 100 msec.⁻¹ are associated with the likely gradients of pressure³. Such winds would take 10³ sec. to replenish the air in the electrojet. Thus convection would not inhibit the process of increase of scale height in an electrojet of this size. Now conduction proceeds better at greater heights⁴. Temperature equilibrium through conduction may be established to distances of the order of 1,000 km. in 10³ sec. at 1,000 km. altitude but only to distances of the order of 10 km. at 200 km. altitude in the same time. Thus a steady model of the dimensions in space and time considered here yields a good approximation to the actual magnetic disturbance conditions in the auroral zones.

It has been shown elsewhere^{1,2} that during such steady disturbance the pressure at 200 km. altitude in the auroral ionosphere can be equal to that at 140 km. in temperate latitudes. This represents an increase in scale height at 150 km. by a factor of about five. This calculation was based on only moderate disturbance. At times of increased disturbance the scale height could change by a factor 10. At these times the temperatures at 200 km. altitude would be increased by amounts of order 1,000° K. Such increases in temperature are sufficient to cause the ejection of hot neutral particles upwards and outwards to populate the magnetosphere, where they could be afterwards ionized by solar radiation to modulate the density of the whistler medium. These density fluctuations would in turn cause variations in the low-frequency phenomena in the magnetosphere such as whistler and dawn chorus propagation. Such variations in density of the background medium would modulate the rate of scatter and of degradation of energy of geomagnetically trapped radiation.

The escape of gases from the auroral zone to interplanetary space is also inevitable with such heating⁵, the lighter molecules hydrogen and helium having the greatest probability of escape. This would explain the representations of earth gases in the spectrum of the counter glow (Gegenschein)⁶ and also

their enhancement with geomagnetic disturbance. Conceivably joule heating in the auroral zones plays an important part in the problem⁵ of the helium balance in the atmosphere.

The theory suggests that static models of the ionosphere above 100 km. and the exosphere may only be adequate for an average picture. This region is dynamically dependent on geomagnetic disturbance and at a given instant its structure may differ significantly from the average. A bulge must develop in the ionosphere above disturbance electric currents. Moreover, since the movement of ionization across the geomagnetic field is inhibited in and above the *F* region of the ionosphere, field aligned inhomogeneities in electron density would project upwards from the parent electric current.

K. D. COLE

Antarctic Division,
Department of External Affairs,
Melbourne.

¹ Cole, K. D., *J. Phys. Soc. Japan*, **17**, 184, Suppl. A-1 (1962). Intern. Conf. Cosmic Rays and Earth Storm, Part I.

² Cole, K. D., *Austral. J. Phys.*, **15**, No. 2 (1962) (in the press).

³ Cole, K. D., *Nature*, **194**, 42, 75 (1962).

⁴ Nicolet, M., *Physics of the Upper Atmosphere*, edit. by Ratcliffe, J. A. (Pergamon Press, 1960).

⁵ Mitra, S. K., *The Upper Atmosphere*, second ed. (The Asiatic Society, Calcutta, 1952).

⁶ Hope, E. R., Defence Research Board, Canada, Trans. No. T65R. Seven papers by I. S. Astapovich, V. G. Fesenkov, N. B. Divair and M. G. Karimov.

PHYSICS

Optical Refractivity of Free Electrons

A NUMBER of experiments have been reported recently in which electron densities have been determined from the refractivity of free electrons in the visible region of the spectrum¹⁻³. In none of these, however, has an independent check been made on the values obtained. We wish to report some recent measurements of the optical refractivity of free electrons in a hydrogen plasma in which simultaneous determinations of electron density are obtained from the Stark effect broadening of H_β and H_γ (ref. 4) and from a measurement of the absolute continuum intensity. A measurement of the electron temperature from the ratio of the total line intensity of H_β to the continuum⁵ is used to confirm the high degree of ionization obtained and the dominant role of the free electrons in determining the refractive index.

The plasma was produced in an electromagnetic *T*-tube⁶ and the refractivity measured using a Mach-Zehnder interferometer. A commercial xenon flash-lamp was used to produce the fringes which were recorded on a streak camera⁷, with a time resolution of ~ 0.1 μ sec. The fringe system was perpendicular to the slit of the streak camera and the fringe shift (Fig. 1) recorded as a function of time as the shock passed the plane of observation. An interference filter ($\lambda \sim 5530$ Å.) in front of the slit served to overcome the self-luminosity of the plasma.

The refractive index of free electrons is given by classical dispersion theory. The frequency of light is much greater than the plasma frequency under the