



Fig. 2

It is thus evident that radio noise observations can be of special value in indicating *D*-layer ionization by the absorption effects on the galactic radio waves reaching the earth when solar radio emissions are small, or when the absorption precodes a solar radio burst. The time lag in the latter case might be interpreted as follows: the ultra-violet radiations giving rise to the enhanced *D*-layer ionization might be due to a solar disturbance travelling outwards from the sun, the electron density in the solar envelope being too great (see Saha³, Martyn⁴) to allow radio-frequency waves to escape until the disturbance has reached the corona.

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J. S. HEY
S. J. PARSONS
J. W. PHILLIPS

Ministry of Supply, O.R.G. (W. & E.),
Broadoaks, West Byfleet,
Surrey.
Aug. 20.

¹ Appleton and Hey, *Phil. Mag.*, **37**, 73 (1946).

² Jansky, *Proc. Inst. Rad. Eng.*, **20**, 1920 (1932); **21**, 1387 (1933); **23**, 1158 (1935); **25**, 1517 (1937).

³ Saha, *Nature*, **158**, 599 (1946).

⁴ Martyn, *Nature*, **159**, 26 (1947).

Radio Echoes from the Aurora Borealis

DURING the night of August 15–16, 1947, radio echoes were obtained apparently arising from a luminescent cloud which appeared near the end of an aurora streamer. The apparatus, which has been described elsewhere^{1,2}, was in use for the study of meteoric ionization simultaneously on frequencies of 72 Mc./s. and 46 Mc./s. At Aug. 16d. 00h. 10m. U.T., an echo was observed intermittently on the 46 Mc./s. equipment at a range of 480 km. By 00h. 20m. the amplitude had increased to three times the normal noise-level. It then decreased with slow fluctuations in intensity, and after twenty minutes was lost in the noise-level at 00h. 30m. U.T. A second echo appeared

at 460 km. range at 00h. 25m. U.T. and lasted for four minutes. Also at 00h. 10m. U.T., an increase in noise-level was apparent on both 72 and 46 Mc./s. equipments over the range 450–600 km. The noise increase persisted and increased in range to 700 km. by 00h. 35m. U.T., when it disappeared. Simultaneously with the appearance of the echoes, a faint blue-grey auroral cloud appeared near the zenith at the upper tip of one of the streamers, which were at that time covering the whole of the northern sky. The streamers receded from the zenith but the cloud grew in intensity, and at 00h. 35m. U.T. broke into nine striations and rapidly faded. The radio echoes thus vanished when the cloud became striated. The entire aurora was visible from darkness on August 15d. to August 16d. 02h. 30m. U.T., but apart from the effects recorded above no other unusual echoes were observed.

It may be assumed that this auroral cloud gave rise to an ionospheric type of radio echo rather than the scattering from a line source which is characteristic of the transient meteoric echoes. In this case the intensity of the ionization may be estimated, since the echoes were visible on the 46 Mc./s. equipment but not on 72 Mc./s. The critical frequency, therefore, lies within this frequency range. Applying the usual formula for the critical frequency³:

$$N = 1.24 \times 10^{-8} f^2,$$

where N is electron density/c.c. and f is ordinary ray critical frequency in c./s., we obtain an ionization density in the range

$$2.6 \times 10^7 - 6.5 \times 10^7 \text{ electrons/c.c.}$$

This is about a hundred times greater than the normal ionization density in the *F*-region during the night.

The cause of the general noise increase from 450 to 700 km. observed on both frequencies may be due to the reflexion of the transmitted signal from a large number of subsidiary scattering points associated with the main cloud.

Since the auroral cloud was visible near the zenith, the measured range of 480 km. may be assumed to be the height of the cloud above the earth's surface. This height falls well within the range of aurora heights measured by Störmer from visible observations during the years 1911–44⁴.

This appears to be the first record of reflexions from aurora on frequencies well above the critical *E*- and *F*-layer frequencies. It seems possible, however, that some of the sporadic *E*-layer effects found by workers in polar regions^{5,6} may be cases of direct reflexion from the aurora forming in the 100 km. region.

These observations were made at the Jodrell Bank Experimental Station of the University of Manchester; lat. 53° 13' 53" N., long. 2° 18' 11" W.

A. C. B. LOVELL
J. A. CLEGG
C. D. ELLYETT

Physical Laboratories,
University,
Manchester.
Aug. 31.

¹ Prentice, Lovell and Banwell, *Mon. Not. Roy. Ast. Soc.*, in the press

² Lovell, Banwell and Clegg, *Mon. Not. Roy. Ast. Soc.*, in the press; see also *Nature*, **159**, 119 (1947) and **160**, 75 (1947).

³ Appleton and Bulder, *Proc. Phys. Soc.*, **45**, 208 (1933).

⁴ Störmer, *Terr. Mag. and Atmos. Elect.*, 501 (Dec. 1946).

⁵ For example, Appleton, Naismith and Ingram, *Phil. Trans.*, **236**, 191 (1937).

⁶ Pierce, *Phys. Rev.*, **71**, 88 (1947).