Letters

Association between VLF Emissions and Flickering Aurora

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During a VLF experiment at Fairbanks, Alaska (geographic position 64°51′N, 147°32′W; geomagnetic latitude 65°N), an unusual chorus type of emission with a warbling or fluttering sound was heard on four different occasions. An example of the spectrum of the emission is presented in Figure 1, which shows a series of bursts in the 1000- to 1800-cps range. Some of the bursts, which last for 1 to 3 seconds, show a well-developed fine structure with several sharply rising tones at irregular spacing, each lasting about 0.1 second. The emission bursts were associated with active periods in the aurora where groups of flashes or flickerings took place and, in the opinion of the observer, each of the short, sharply rising tones was associated with a flash in the aurora. Also seen in Figure 1 is a band of hiss in the 600- to 1200-cps range.

During this experiment, VLF signals were recorded for 16 nights, between September 3 and October 14, 1963. Most of these nights were magnetically disturbed. Bursts similar to those in Figure 1 were observed on four nights, for which relevant data are given in Table 1.

During the night of September 16 the bursts of emissions were observed to be associated with active periods in the aurora. At 0105 on that night there was a rayed band (a_3R_2B4b) taken from the *International Auroral Atlas* [1963] with red lower border and brightness 3 or 4 through the zenith. Quiescent and active periods alternated in this band. During the active periods, which coincided with VLF emission bursts, a series of fast movements of rays or kinks along the band took place.

At 0120 the rayed band had disappeared, and there was a patchy glow (p_3SP2c) of

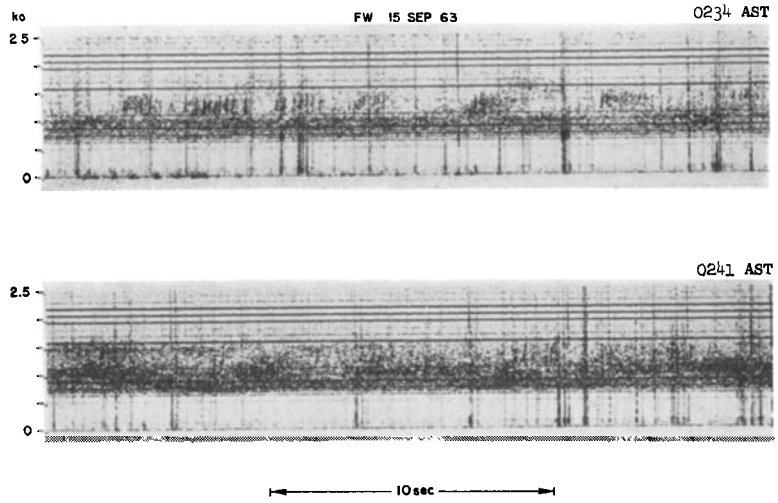

Fig. 1. Spectra of chorus type of emission observed in association with flickering aurora.

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TABLE 1. VLF Burst Data on Magnetically Disturbed Nights

Date, 1963	Hours, AST	K_p	K	Aurora
Sept. 15	0200–0400	5−	7	No data
Sept. 16	0045–0215	5−	7	$a_2R_2B4b \rightarrow p_3SP2c$
Oct. 11	0400–0500	3+	5	Overcast
Oct. 14	0130–0245	5+/4+	x	Overcast

strength 2 or 3 covering the whole sky. The borders between bright and dark patches were sharp. Again quiescent and active periods alternated. During active periods dark patches would flare up, bright patches would fade suddenly, and the pattern would change continuously. The active periods would typically last a couple of seconds, during which VLF emission bursts occurred. Quiescent periods of a few-seconds' length in between were not associated with emission bursts.

These observations were made while the observer was standing outside the building housing the VLF receiver and was watching the aurora while listening to the monitor speaker on the receiver.

Unfortunately it was not possible to observe association between the emissions and aurora during later nights because the sky was overcast.

Several reports on listening for emissions during aurora have been published. *Martin et al.* [1960], *Morozumi* [1963], and *Jørgensen and Ungstrup* [1962] report hiss during aurora. This, however, is a different phenomenon from the one treated here. *Jorgensen and Ungstrup* [1962] and *Pope* [1959] state that they did not find any association between chorus and aurora.

At Kerguelen, *Renard* [1961] found chorus during flaming or flashing aurora, and, when such aurora occurred near zenith, the chorus sounded like crickets. During this type of chorus the recordings from the 3914-A photometer showed a series of rapid peaks. *Burton and Boardman* [1933] found association between flashing aurora and emissions in New Hampshire. They reported that nearly every flash coincided with a static crash possessing a frying sound. The crashes were in most cases followed by swishes, usually of the descending variety, although occasionally a short ascending whistle occurred simultaneously with the start of the descending swish.

In view of the very few reports of association between chorus and aurora it seems to be a rare event that is observed only when flashing or flaming aurora occur near the observer's zenith.

It is suggested that an attempt be made to determine the time delay between emission bursts and auroral flashes, since this interval would give information regarding the height at which the emissions were generated.

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References

Burton, E. T., and E. M. Boardman, Audio-frequency atmospherics, *Proc. IRE, 21,* 1476–1494, 1933.

International Auroral Atlas, published for the International Union of Geodesy and Geophysics, Edinburgh University Press, Edinburgh, Scotland, 1963.

Jørgensen, T. S., and E. Ungstrup, Direct observation of correlation between aurorae and hiss in Greenland, *Nature, 194,* 462–463, 1962.

Martin, L. H., R. A. Helliwell, and K. Marks, Association between aurorae and VLF hiss observed at Byrd Station, Antarctica, *Nature, 187,* 751, 1960.

Morozumi, H. M., Semidiurnal auroral peak and VLF emissions observed at the South Pole, 1960, *Natl. Acad. Sci., IG Bull., 73,* 16–23, 1963.

Pope, J. H., An investigation of whistlers and chorus at high latitudes, *Geophys. Inst., Univ. Alaska, Sci. Rept., 4,* April 1959.

Renard, C., Variations diurnes et cycliques de l'intensité des bruits radioélectriques naturels de très basses fréquences, *Compt. Rend., 252,* 1365–1367, 1961.

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