THE ULF MODULATION OF ELF-VLF EMISSIONS CLOSE TO THE MAGNETOSPHERIC BOUNDARY

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ABSTRACT. The spatial extent and temporal behaviour of quasi-periodic (QP) intensity modulations of 0.5-2kHz ELF-VLF emissions were investigated in a comparative study of data collected at three Antarctic stations. Frequently, the waveforms of the ELF-VLF signals received at each site were identical. The emissions are identified with the periodic modulation of the electron pitch-angle distribution by the propagation of ULF compressional fast-mode waves through a region. In addition to generation close to the equatorial plane, we propose an additional high-latitude source of QP emissions. These emissions are associated with regions of minimum-*B* produced by the dayside compression of the magnetosphere close to the magnetopause.

1. Introduction

It has often been observed that naturally occurring ELF-VLF 0.5-2kHz noise is modulated quasi-periodically in the range ~10-50s. These repetitive noise bursts, known as quasi-periodic (QP) emissions, were first described by Helliwell (1965) and Carson et al. (1965). They are seen in space and on the ground at high latitudes beyond the plasmapause (Tixier and Cornilleau-Wehrlin, 1986).

It is generally accepted that the modulation process involves the compressional component of an ULF wave acting on an existing source of ELF-VLF noise in the equatorial regions of the outer magnetosphere (Coroniti and Kennel, 1970; Haugstad, 1976; Sato and Fukunishi, 1981; Tixier and Cornilleau-Wehrlin, 1986). As the wave alternately increases and decreases the magnetic field, it modulates the pitch-angle distribution of the particles to produce the distinctive QP ELF-VLF emissions.

The most likely source of compressional magnetic pulsations is in the solar wind upstream of the

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earth's bow shock (Odera, 1986). The necessary conditions are satisfied on the dayside with transmission through the sub-solar point during intervals of low IMF cone-angle (Greenstadt and Olson, 1976).

In this paper, new insights into the spatial extent and temporal behaviour of QP emissions are gained using simultaneous observations from three Antarctic stations.

2. Observations

The intensity in a narrow-band ELF-VLF channel 0.5-1.5kHz was recorded at Halley (L=4.2, MLT=UT-3.5), and in a 1-2kHz channel at Siple (L=4.2, MLT=UT-5). Both stations lie near to the nominal position of the plasmapause. At South Pole (L=13.6, MLT=UT-3.5), situated close to the nominal dayside cusp, intensities in both 0.5-1kHz and 1-2kHz channels were recorded. Magnetic field measurements of the H- and D-components of the earth's magnetic field at South Pole and Halley, and of the D-component at Siple, were available for analysis. Data used in the analysis were obtained or later averaged at 1s intervals.

3. Discussion

A study of the diurnal occurrence of QP events during September 1986 showed their distribution to be similar at all three sites, with a maximum of occurrence just before local magnetic noon clearly evident at South Pole and Halley. Frequently, the waveforms of the ELF-VLF signals observed simultaneously at each site were strikingly similar. Fig.1 shows a 15min interval on 14th September 1986, part of an event during which there was an excellent one-to-one relationship of the ELF-VLF signals at South Pole, Halley and Siple. In contrast, although having similar frequency structure, the detailed waveform of magnetic pulsations at a particular station generally showed little coherence with the ELF-VLF signals, or with the magnetic pulsations at other stations.

Whilst compressional ULF waves drive the modulation process, it is uncertain whether this involves standing or propagating compressional waves (Sato and Kokubun, 1980; Sato and Fukunishi, 1981). Although there was little discussion of, or evidence for, standing waves when they were invoked by Sato and Fukunishi in 1981, global compressional modes in the magnetosphere, often known as cavity resonances, have been subjected to considerable study since 1985. The most obvious resonance is that associated with the dayside magnetosphere and its harmonics, with boundaries at the magnetopause and plasmapause (Allan and McDiarmid, 1989). Lysak and Lee (1992) have shown that in a three-dimensional dipole geometry it is possible to establish compressional resonances at frequencies in the Pc3 range, although the specific frequencies and radial locations of dominant power depend greatly on the azimuthal wave number assumed for the external source of excitation, a parameter that has not yet been determined experimentally. However, two factors argue against the importance of such standing-wave modes. Firstly, Anderson et al. (1989, 1990) report no evidence for global-cavity modes in several years of AMPTE CCE magnetic-field data, despite equipment sensitivity adequate to discern any narrowband compressional activity of the sort predicted by computer simulations. Secondly, as Engebretson et al. (1990, 1991a) have shown, the centre frequency of the QP emissions and magnetic pulsations observed at South Pole were proportional to the magnitude of the IMF, which