ULF WAVES OBSERVED WITH MAGNETIC AND ELECTRIC SENSORS ON GEOS-1

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Abstract. Preliminary results on ULF waves in the range 0.2–11 Hz detected on board GEOS-1 are described. In this frequency domain one must consider two different categories of emissions: waves with frequencies below the proton gyrofrequency $f_p$ and frequencies above. Belonging to the first category are the structured ULF events called 'pearls' which are very often observed on the ground, but which were observed only twice on board GEOS-1 in seven months of operation. Most of the monochromatic emissions with a frequency below $f_p$ were detected while the satellite was near its apogee ($L \approx 7$). These waves are left hand polarized, perpendicular to the magnetic field. Other monochromatic events, whose frequency lies above the proton gyrofrequency are predominantly right hand polarized perpendicular to the magnetic field, whereas phenomena with complex, harmonically related structures, also detected above the proton gyrofrequency, are clearly polarized along the magnetic field. These waves can be probably interpreted in terms of Ion Bernstein modes.

We make here a morphological description of these different waves. We present preliminary results which relate their occurrence or characteristics to the parameters of the magnetospheric plasma. This study is mainly based upon data obtained via the magnetic detector although on some occasions, the electric component of the waves has been also identified and measured.

1. Introduction

GEOS is equipped with detection chains of magnetic and electric field fluctuations in the frequency range 0.05–11 Hz. This range covers three types of pulsations from low frequency to high frequency: Pc-3, Pc-1–Pi-1, and ELF waves. Taking into account the trajectory of the satellite (see in this issue the general introduction to GEOS where the orbital configuration is given), the proton gyrofrequency falls generally within the frequency domain detected by the sensors.

The study of Pc-3 is hampered by the fact that the spin rate of the satellite which is approximately equal to 0.18 Hz, has obliged us to introduce a filter at this frequency. The analysis of these waves is therefore more complicated than the analysis in the rest of the passband and we have not yet tried to study these waves, whose geophysical importance has however been stressed in a series of recent papers (see for instance Singer et al., 1977; Cummings et al., 1978; Hughes et al., 1978).

Since a long time intensive studies of Pc-1–Pi-1 have been carried out using ground data, and a classification of the different types of events which can be observed in this frequency range has been made based on their spectral shapes on

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a three dimensional representation (Gendrin, 1970). Generally these pulsations observed on ground have frequencies below the minimum proton gyrofrequency along the field line and they are left hand polarized. One considers that these pulsations are ion cyclotron waves which can propagate along the field line at frequencies below the proton gyrofrequency.

Much was expected from direct in situ observations of these waves by means of satellites. The first measurements were carried out on board OGO-3 and -5. The trajectory of these satellites was such that they explored a large volume of the magnetosphere, leading Heppner et al. (1967, 1970) to find a Pc-1 distribution with a maximum near the magnetopause at the 6 hr local time meridian with high percentages extending tailwards near the magnetopause. Fredricks and Russell (1973) observed ion cyclotron waves in the polar cusp. Using data from Explorer 45, Taylor et al. (1975) found, on the contrary, about ten cases occurring near the plasmapause and in the proton ring current but they could not conclude that the waves were generated by the ion cyclotron instability or that the ion cyclotron waves played a dominant role in the loss of the ring current ions. A detailed comparison between the time of occurrence of these waves and the particle distribution functions led Taylor and Lyons (1976) to distinguish between two categories of waves: those which were associated with increasing fluxes of protons and those which were not. In fact the waves studied by these authors cover a wide frequency range (1–30 Hz) and no detailed spectral analysis of these waves was available. With a similar purpose in mind and with a similarly poor spectral information, Kintner and Gurnett (1977) have looked at records from Hawkeye 1. Only five events (over a period of 18 months) were detected and they were confined to the plasmasphere.

A statistical study of the occurrence of Pc-1 recorded on ATS-1 as a function of the local time and the magnetic activity was reported by Bossen et al. (1976a); these authors found a maximum in the afternoon sector at geostationary orbit. Comparison between ground measurements in the conjugate area and on board ATS-1 led the authors to conclude that most of the events detected in situ are IPDP's with a rather large amplitude (Bossen et al., 1976b); this result is in agreement with the preferential occurrence of pulsations around 18:00 LT.

Waves with frequency above the proton gyrofrequency have been detected in the magnetosphere. These pulsations were considered to belong to the ELF range by Russell et al. (1970). The events observed on board OGO-3 occur only in the outer plasmasphere (L = 4–5) and are confined near the magnetic equator (Russell et al., 1970). These waves are propagating perpendicular to the magnetic field. Similar phenomena were detected at L ≈ 2–3, on board IMP-6 and Hawkeye-1 by Gurnett (1976) who shows clearly the harmonic structure of such emissions. Gurnett confirmed the strict localization of this noise near the magnetic equator.

Another type of electrostatic (or quasi electrostatic) noise attributed to plasmapause gradients has also been detected by Kintner and Gurnett (1978) in the frequency range above the proton gyrofrequency.