transient oscillation at the local toroidal mode eigen-period result in the wave packet structure in Fig. 1. Note that the cavity resonances have the form of a quarter-wave and its higher harmonics, and that they appear to be evanescent inside the radial position of the appropriate toroidal mode resonance.

Monochromatic resonant ULF pulsations are usually attributed to steady-state driving forces such as the Kelvin-Helmholtz instability on the surface of the magnetopause. The above model shows that impulsive sources may also drive monochromatic resonances via the intermediary of magnetospheric cavity resonances.

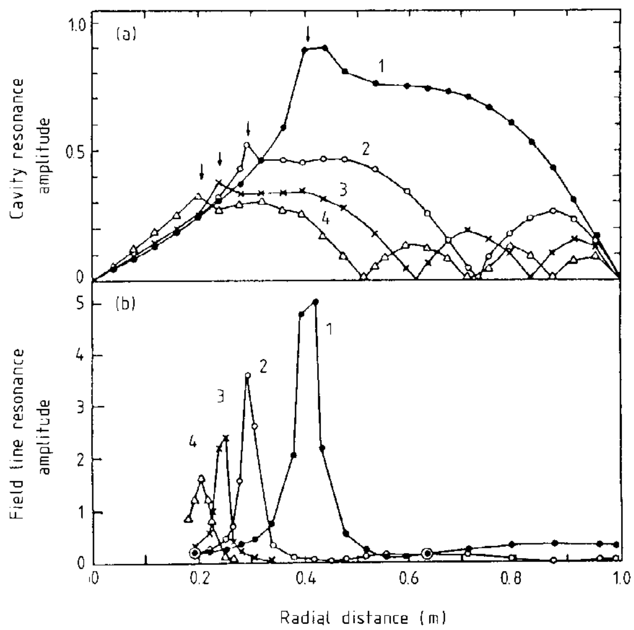

Fig 2 (a) Radial variation of the amplitude of the cavity resonance harmonics up to order 4 and (b) their associated toroidal mode monochromatic resonances.

The use of geomagnetic pulsations in determining magnetospheric plasma properties

B. J. Fraser

Department of Physics, University of Newcastle, NSW 2308, Australia.

The existence of cold or cool heavy ions in the magnetospheric plasma of the earth has been known since early GEOS-I ion composition experiment results in 1977 (Geiss *et al.* 1978). Helium (He^+) and oxygen (O^+) relative concentrations of up to 50% of the total ion concentration were found. The reliability of these particle concentrations are difficult to estimate. Unresolved wave modulations, giving rise to plasma flows and other problems including spacecraft charging, make concentration measurements difficult. Mauk (1984) has recently shown, by computer simulation, that particle concentrations measured in association with linear interaction between a wave and He^+ ions may be artificially inflated by an order of magnitude. An extremely simple and sensitive measure of heavy ion (He^+, O^+) relative ion concentrations can be made using the bounding surfaces associated with the propagation of ion cyclotron waves in a multicomponent cold plasma. Obviously, measurements can be made only in the presence of ion cyclotron wave energy which occurs in the Pc1-2 geomagnetic pulsation frequency range (0.1-5 Hz).

The purpose of this paper is to present the properties of ion cyclotron waves seen by magnetometers on board the ATS-6 geostationary spacecraft at L=6.6 and interpret them in terms of simple multicomponent cold plasma propagation theory. This procedure leads to the application of wave diagnostic techniques to determine relative He^+ and O^+ ion concentrations.

The typical dynamic spectra recorded by ATS-6 show that the wave spectrum is organized by the He^+ cyclotron frequency (f_{He}). Two 4 month data sets of similar events are available, one from 1974 when ATS-6 was situated 12°N of the geomagnetic equator and the other when the spacecraft was on the geomagnetic equator. Figure 1 shows polarization ellipticity plotted as a function of wave frequency normalized to the equatorial proton cyclotron frequency (f_H). The $\lambda = 12°$ data are mapped back to the equator using the Olsen-Pfitzer 1977 geomagnetic field model. The He^+ slot is apparent in both plots by the absence of data points around f_{He}. For the $\lambda = 0°$ data most waves are LH-polarized with some almost linear cases observed. Off the equator the wave regime above

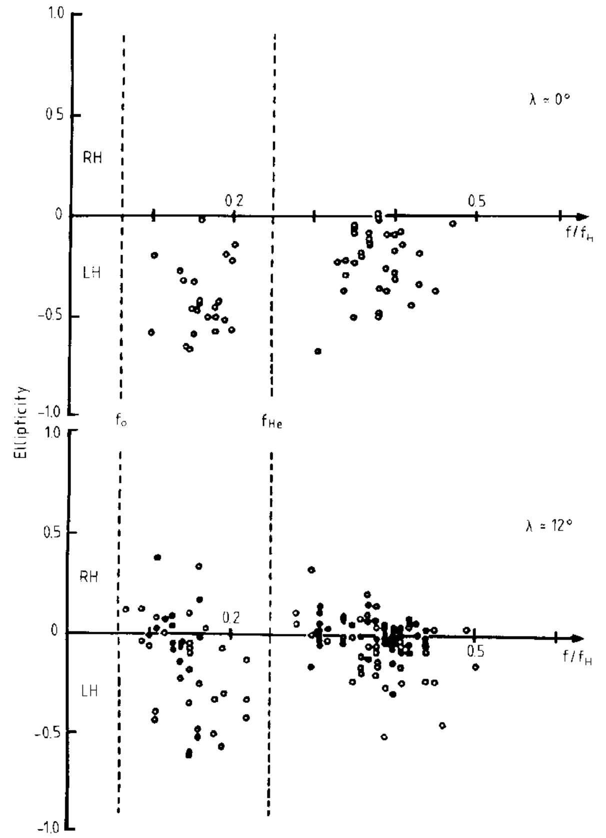

Fig 1 Wave ellipticity variation with normalized frequency. The solid data points indicate the first 2 months of data off the equator..

f_{He} changes character to almost completely linear polarization. Below f_{He} the waves remain LH with the exception of a small linear group in the frequency range (0.1–0.2) f_H, which is just above the oxygen cyclotron frequency (f_O). These linearly polarized waves observed off the equator indicate the presence of O^+ in the thermal plasma (Fraser & McPherron 1982). O^+, with concentrations comparable to or greater than He^+, has been observed in the thermal plasma at synchronous orbit (Geiss *et al.* 1978).

Current models suggest that ion cyclotron wave amplification is initiated off the equator and waves propagate along the field line direction with increasing f/f_H towards the equator and then with decreasing f/f_H into the opposite hemisphere. As the waves propagate away from the equator their characteristics are affected by multicomponent plasma bounding surface properties associated with resonances, cut-offs, and polarization reversals. Using these properties a simple model can be invoked to adequately explain all the ion cyclotron wave properties observed by ATS-6.

Knowledge of the critical frequencies associated with the wave resonances and cut-offs provides a simple method for determining relative cold heavy ion concentrations in the vicinity of the spacecraft. The most accurately determined critical frequency from wave spectra is the crossover frequency defined by a polarization reversal. The distribution of He^+ concentrations determined from ATS-6 ion cyclotron waves observed off the equator in 1974 and on the equator in 1975, assuming a two-ion plasma (H^+, He^+), are plotted in the histograms in Fig. 2. He^+ concentrations are generally $< 10\%$, a result which is in agreement with linear theoretical calculations of wave spectra (Roux *et al.* 1982). It also appears that very low He^+ concentrations are seen less frequently at the equator. The technique may be extended to a three-ion plasma (H^+, He^+, O^+) for the simultaneous determination of He^+ and O^+ concentrations. There is still a lot of quantitative work to be done and it is anticipated that further understanding of wave propagation models will lead to the extension of diagnostic studies.

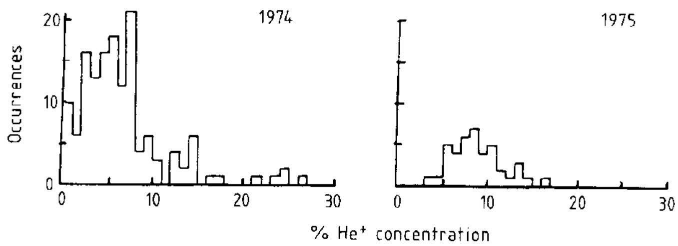

Fig 2 Distribution of He^+ concentrations determined from the crossover frequency off the equator (1974), and on the equator (1975).

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