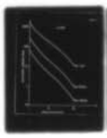
AD-A074 729   MARYLAND UNIV COLLEGE PARK INST FOR FLUID DYNAMICS --ETC F/G 4/1
BALLOON PROGRAM. (U)
JUL 75   N00014-67-A-0239-0023

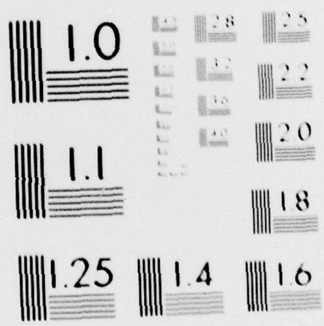
UNCLASSIFIED   NL

1 OF 1

AD
A074729



END
DATE
FILMED
11-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TRIP REPORT

Balloon Program - University of Maryland
Roberval, Quebec, Canada July 1975

During the month of July, 1975 the University of Maryland, assisted by collaborating groups from the University of Houston and the Norwegian Institute of Cosmic Physics (NICP), conducted a series of high altitude measurements of x-rays, electric fields, and VLF radio waves. These measurements formed part of a special Siple-Roberval campaign which included VLF direction-finding measurements in the Roberval area by groups from Stanford University, the University of Southampton, and the University of Tokyo.

The scientific purpose of this special campaign was a) to investigate ionospheric effects, in particular precipitation phenomena, induced by natural VLF signals and by signals from the Siple transmitter, b) to perform direction-finding measurements on the magnetospheric signals from the Siple transmitter in order to evaluate results from various types of direction-finding systems and c) to study the positions, movements, relation to the plasmapause, etc., of transmitter signal paths.

The present report deals primarily with the results of the balloon program. Nine (9) launches were made during the period from 3 July through 22 July. A summary of the flight program is attached.

All flights carried an uncollimated 5 inch diameter x 1/2 inch thick sodium iodide detector with a 15 mil. aluminum entrance window to record x-rays in two (2) integral energy channels (>25 and >500 kev) and seven (7) differential energy channels (25-45, 45-65, 65-95, 95-125, 125-175, 175-250, and 250-500 kev). This experiment was provided by the University of

Contract N00014-67-A-0239-0023
NSF-GA-19786

Maryland which was represented in the field by Dr. T. Rosenberg, Dr. D. Matthews, and Mr. C. Gibson.

Four (4) of the flights also carried electric field detectors provided by the University of Houston (Dr. E. Bering and Mr. C. Liles represented this group at Roberval). The remaining five (5) flights carried VLF receivers (0-5 kHz) provided by the NICP (Dr. J. Holtet and Mr. S. Bergersen represented this group at Roberval). On these flights a wire loop around the balloon (in the vertical plane) served as the antenna for the VLF receiver.

The basic telemetry system for all flights was PCM-FM-FM with the digital x-ray data impressed on a 93 kHz VCO. Analog data from the E-field and VLF experiments were impressed on 54 kHz and 165 kHz VCO's, respectively. The telemetry frequency was nominally 149.1 MHz.

Besides the individuals named above, Mr. R. Heer, Jr. (OPP/NSF), LCDR. W. Smith and CDR. W. Cross (ONR/SKYHOOK) and Dr. J. Foster (NRC/Canada) were present at various times as observer/assistants.

With reference to the flight summary, it should be noted that four of the flights were made during geomagnetically disturbed periods. At these times, enhanced x-ray fluxes were recorded. Rapid time variations of the x-ray flux were apparent at most times. On the flights which carried VLF receivers, detailed correlations between emission structures and x-rays were evident. Quick look data available for the E-field measurements also indicated the possibility of interesting correlative features with the x-ray flux.

Data processing and analysis is now underway by the various groups involved. Progress reports and reports for publication will appear at a later date. However, an initial assessment of the flight data obtained suggests that the enhancements in x-ray, VLF, and E-field intensities occurred during events of natural origin. No influence of the Siple transmitter was readily discernible in the data. In only one instance, from 1100-1230 UT, on July 22 (Flight 9), were the Siple transmissions observed at Roberval when a balloon was in the air. In that instance the transmitter signals were weak although there was some indication of triggering. Although the precise reasons remain to be evaluated in depth, perhaps the infrequent occurrence of Siple transmissions at Roberval during the approximately 1-month period of coordinated observations was related to the enhanced level of magnetospheric disturbance encountered at this time.

For the potential benefit of others, it is worth mentioning here what we know of the difficulties that led to the ground level terminations of Flights 1 and 4 at the times of launch.

In addition to the main instrument packages each flight train contained radar reflectors, a parachute, delayed action squib, and (initially) one passive (timer) cutdown device and one command cutdown device. Following the two premature ground level terminations, which subsequently were traced to the command cutdown unit, a second independent passive cutdown device was substituted for the command unit on later flights at the recommendation of the ONR representative. Confirmation of termination (cutdown) was obtained on all subsequent flights by observation of altimeter readout and telemetry signal strength.

The command cutdown units (designed and constructed by the Berkeley group under the direction of Professor F. Mozer and Mr. R. Herman), which were supplied to us by ONR, operate on a frequency of 138.54 MHz, and are actuated by a two-tone-VLF signal (988.7 and 1617.6 Hz) with a time delay feature. The payload telemetry frequency was nominally 149.1 MHz at approximately 0.5 Watt. We were able to demonstrate that the proximity of the telemetry transmitting antenna to the command receiver antenna (which in the case of the x-ray/VLF payload configuration was ~20 feet) could lead to overloading the command receiver input and consequent squib firing. In the x-ray/E-field payload configuration, the telemetry and command receiver antennas were more than 70 feet apart. This separation was sufficient apparently to avoid overloading the receiver to the extent that squib firing would occur, but it is likely that even in this case the receiver input sensitivity was impaired because of clamping by the AGC. Calculations performed by the Berkeley group after we consulted with them confirmed the nature of the problem. On the last flight a command unit was included with the separation between telemetry and command receiver antennas increased to 150 feet. This balloon reached a maximum altitude of 90,000 feet and was a slow sinker. When it sank to just above 60,000 feet we attempted unsuccessfully to command the termination. This unsuccessful attempt provided further confirmation of the impairment of receiver sensitivity even for the relatively large separation employed on this particular flight. The flight was terminated by the 60,000 feet safety feature in the passive cutdown unit.

Balloon Flight Summary - Roberval, Quebec, Canada July 1975

Flight No.	Launch (UT)	Terminate (UT)	Instrumentation	Remarks
1 (3 July)	0636	0636	X-RAY/VLF	Ground Level Squib Firing No Data
2 (4 July)	0501	0630	X-RAY/VLF	Poor Teleletry From Launch No useful data obtained
3 (5 July)	0426	1340	X-RAY/E-FIELD	Quiet Conditions
4 (8 July)	0726	0726	X-RAY/VLF	Ground Level Squib Firing No Data
5 (9 July)	0828	2023	X-RAY/E-FIELD	Geomagnetically Disturbed Enhanced X-Rays
6 (11 July)	0844	1340	X-RAY/VLF	Geomagnetically Disturbed Enhanced X-Ray and VLF Emissions
7 (15 July)	0932	1725	X-RAY/VLF	Geomagnetically Disturbed Enhanced X-Ray and VLF Emissions
8 (18 July)	0920	1643	X-RAY/E-FIELD	Geomagnetically Disturbed Enhanced X-Rays
9 (22 July)	0802	1400	X-RAY/E-FIELD	Quiet Conditions Balloon Slow Sinker

SEARCH FOR ELECTRON PRECIPITATION INDUCED ARTIFICIALLY†

T. J. Rosenberg and J.C. Foster
Institute for Fluid Dynamics and Applied Mathematics
University of Maryland, College Park, Maryland 20742

ABSTRACT

Positive results pertaining to the triggering of electron precipitation by natural VLF signals suggest that artificial stimulation, for suitable conditions of the magnetospheric plasma and energetic electron populations, could also lead to electron precipitation. Two series of x-ray measurements, coordinated with the operation of the VLF transmitter at Siple Station, Antarctica, have not found evidence of such an effect. However, in no case was there evidence of the transmitted signal or triggered emissions being received at the Siple conjugate point. It is suggested that the negative results to date are related to the absence of suitable conditions for triggering on the Siple field line, but the prospects remain good for successfully triggering electron precipitation by artificial means.

INTRODUCTION

In recent years active experiments have played an increasingly important role in studies of the magnetosphere and ionosphere. Here we consider one such active experiment, the controlled stimulation of VLF emissions by a ground-based transmitter, with special emphasis on the implications for the artificial stimulation of energetic electron precipitation.

Early studies by Helliwell et al., (1964) and Kimura, (1968) showed that Morse-Code signals from U.S. Navy communication transmitters, propaga-

†To be published in the Proceeding of the International Conference on "X-Rays in Space" held at the University of Calgary, Alberta, Canada Aug. 14-21, 1974, in press 1975.

ting through the magnetosphere in the whistler mode, could trigger emissions. Triggering by these fixed-frequency transmissions occurred near one-half the minimum electron gyrofrequency along the path traveled implying an equatorial interaction. Most theories attribute the generation of VLF emissions to the transverse electron cyclotron resonance instability occurring near the equatorial plane (Helliwell, 1967, 1969; Sudan and Ott, 1971; Nunn, 1971). Brice, (1964) and Helliwell, (1969) predicted that electron precipitation should accompany the generation of VLF emissions by this process.

OBSERVATIONS AND RESULTS: NATURAL STIMULATION

The search for an electron precipitation effect associated with VLF emission generation began with a series of balloon-borne x-ray measurements from Siple Station, Antarctica in 1971. Passive monitoring of natural VLF radio noise was conducted at Siple and its conjugate point near Roberval, Quebec, Canada. Siple Station is situated near the average location of the plasmapause. Since the plasmapause is a region of enhanced VLF emission activity and since strong whistler ducting is not found outside of its position, it was appropriate to look there for a high degree of correlation between temporal features in electron precipitation and VLF noise.

Data were obtained which showed highly correlated bursts of x-rays and VLF emissions (Rosenberg et al., 1971; Foster, 1973; see also Figure 2 in paper by J.C. Foster in this Proceedings). The emissions in this case appeared to be triggered by whistlers. Analysis of the data supported the interpretation that an electron cyclotron resonance interaction was the dominant mechanism responsible for the burst generation.

Electron precipitation triggered by whistlers may occur even in the absence of observable emissions. This was suggested by Helliwell et al.,

(1973) who showed correlations between whistlers and amplitude anomalies in sub-ionospheric VLF propagation.

OBSERVATIONS AND RESULTS: ARTIFICIAL STIMULATION

The positive results pertaining to the triggering of electron precipitation by natural VLF signals offer confidence that artificial stimulation for suitable conditions of the magnetospheric plasma and energetic electron populations, could also lead to electron precipitation.

With the installation and successful operation of a high-power VLF transmitter at Siple Station, it has been possible to trigger VLF emissions in a wide variety of formats (Helliwell and Katsufrakis, 1974). However, in searching for an electron precipitation effect, it must be realized that a wide range of electron energies might be involved, not all of which may be amenable to measurement by bremsstrahlung observations from balloons. This point is illustrated for the Siple meridian in Figure 1. Three different conditions on the location of the plasmapause relative to Siple Station ($L \sim 4.2$) are indicated: a) the plasmapause is equatorward of Siple (N_e = 1/cc); b) the plasmapause is overhead of Siple (N_e = 20/cc); c) the plasmapause is poleward of Siple (N_e = 100/cc). Note that for the higher frequencies at and within the plasmapause, the resonant electron energies may be too low for measurement by the balloon x-ray method. Although the constant frequency transmitted signal would resonate initially with a narrow band of electron energies, once an emission was triggered a wider range of energies would be involved. But to measure the lowest energies, or to examine the pitch angle distribution, a rocket would be required.

Another consideration that is potentially important in the search for a precipitation effect pertains to which end of the field line the particle measurement is made. For the case in which the triggering signal originates in the southern hemisphere (VLF transmitter), precipitation of electrons will occur predominantly at Siple Station because the gyro-resonant electrons travel initially in the direction opposite to that of the trigger wave (Figure 2B). In this case only a fraction of backscattered electrons would be expected to precipitate in the northern hemisphere. On the other hand, when the trigger signal originates in the northern hemisphere (whistler), a significant fraction of gyro-resonant electrons will still be precipitated at Siple Station (Figure 2A). This is due to the fact that the equatorial loss cones differ for the two hemispheres because the magnetic field strengths at the conjugate ionospheric intercepts are unequal. The sizes (α) of the equatorial loss cones on the Siple-Roberval field line are such that α_{north} is less than α_{south}. Consequently, electrons with $\alpha_{north} < \alpha < \alpha_{south}$ will, after reflection in the north, be lost over the south. These reflected electrons would retain their initial pitch-angle distribution if no additional pitch-angle scattering occurred within the interval of one-half the electron bounce time ($\sim$.5 sec).

To date, in coordination with the operation of the Siple VLF transmitter, two series of x-ray measurements have been made in the search for an electron precipitation effect. One series was conducted from Roberval in July and August 1973; the second series was conducted from Siple Station in January 1974. In both series, enhanced x-ray fluxes were recorded on occasions when the transmitter was operating. Frequencies as low as 2.5 kH_z were used. The corresponding resonant electron energies were expected to be sufficiently high, for the magnetospheric conditions encountered, so as to produce x-rays observable from balloons. However, it has not yet been possible to identify unambiguously an artificially stimulated effect in these records. The observed x-ray and emission activity appears to be of natural origin only and related to substorm occurrence.

Since neither the transmitted signal nor any evidence of triggered emissions was observed at Roberval when a balloon was in the air, it is suggested that this negative result is related to the absence of suitable conditions for triggering within the Siple-Roberval flux tube at the times in question. Recent advances in determining the appropriate triggering frequency in the actual duct where propagation is occurring (J. P. Katsufrakis, personal communication), greatly increases the probability in future measurements of successfully gauging when best to launch a balloon.

ACKNOWLEDGEMENTS

This work was partially supported by NSF grants GA-19786 and GV-28841X and by the U. S. Office of Naval Research, Contract No. N00014-67A0239-0023.

REFERENCES

Brice, N., Fundamentals of very-low-frequency emission generation mechanisms, J. Geophys. Res., 69, 4515, 1964.

Foster, J.C., An experimental observation of whistler-triggered electron cyclotron interactions in the magnetosphere, Institute for Fluid Dynamics and Applied Mathematics Technical Note BN-774, University of Maryland, College Park, 1973.

Helliwell, R.A., Low frequency waves in the magnetosphere, Rev. Geophys., 7, 281, 1969.

Helliwell, R.A., A theory of discrete VLF emissions from the magnetosphere, J. Geophys. Res., 72, 4773, 1967.

Helliwell, R.A. and Katsufrakis, J.P., VLF wave injection into the magnetosphere from Siple Station, Antarctica, J. Geophys. Res., 79, 2511, 1974.

Helliwell, R.A., Katsufrakis, J.P. and Trimpi, M.L., Whistler-induced amplitude perturbation in VLF propagation, J. Geophys. Res., 78, 4679, 1973.

Helliwell, R.A., Katsufrakis, J.P., Trimpi, M. and Brice, N., Artificially stimulated VLF radiation from the ionosphere, J. Geophys. Res., 69, 2391 1964.

Kimura, I., Triggering of VLF magnetospheric noise by a low-power transmitter, J. Geophys. Res., 73, 445, 1968.

Nunn, D., A theory of VLF emissions, Planet Space Sci., 19, 1141, 1971.

Rosenberg, T.J., Helliwell, R.A. and Katsufrakis, J.P., Electron precipitation associated with discrete very-low-frequency emissions, J. Geophys. Res., 76, 8445, 1971.

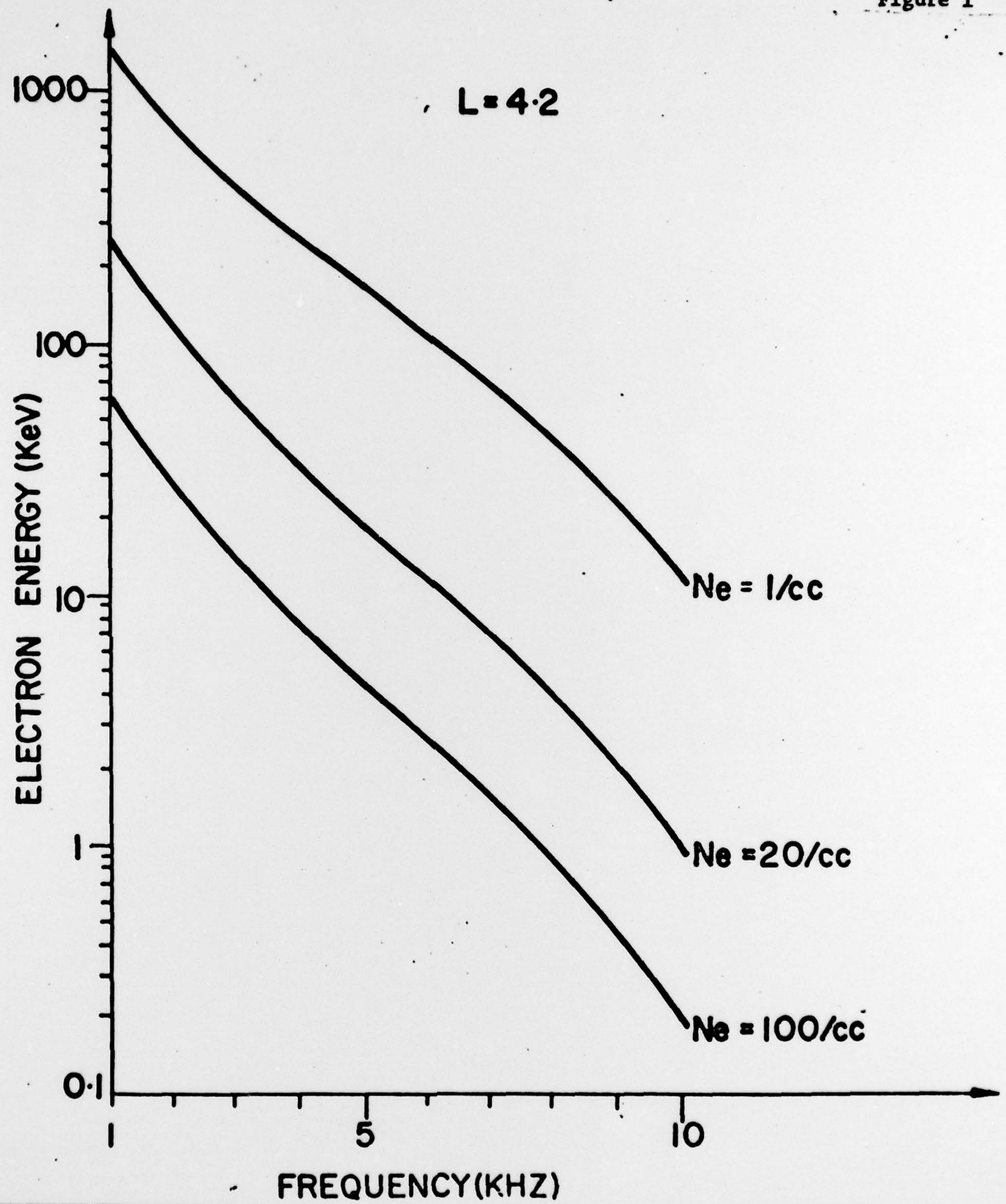
Sudan, R.N. and Ott, E., Theory of triggered VLF emissions, J. Geophys. Res., 76, 4463, 1971.

FIGURE CAPTIONS

Figure 1. Relationship of parallel electron energy and wave frequency for cyclotron resonance at the equatorial plane on the Siple Station field line. Three values of equatorial plasma density are chosen to reflect different conditions on the location of the plasmapause relative to the $L = 4.2$ field line.

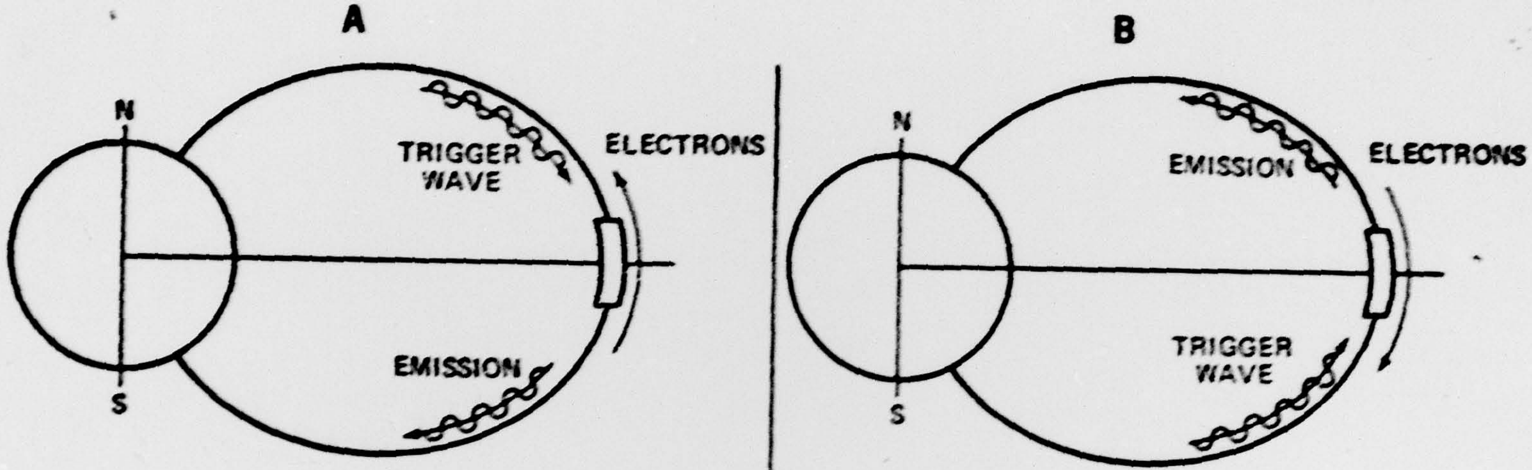
Figure 2. Schematic illustration of the conjugate asymmetry in triggered electron precipitation when the equatorial loss cone angle for precipitation in the north (α_N) is less than the equatorial loss cone angle for precipitation in the south (α_S). In A, the trigger wave originates in the northern hemisphere; in B, the trigger wave originates in the southern hemisphere. The ratio of the flux of precipitated electrons, $R_{N/S}$, is calculated assuming a $\sin \alpha$ pitch angle dependence. The contribution from backscattered electrons is neglected.

Figure 1



L=4·2
1000
100
10
1
0·1
ELECTRON ENERGY (KeV)
Ne = 1/cc
Ne =20/cc
Ne = 100/cc
1
5
10
FREQUENCY(KHZ)

CONJUGATE ASYMMETRY IN TRIGGERED ELECTRON PRECIPITATION



$$\alpha_N < \alpha_S$$

$$\eta = 2\pi A_0 \int j \sin\alpha \cos\alpha \, d\alpha$$

$$j \sim \sin\alpha$$

$$\therefore \eta \sim \sin^3\alpha \sim \alpha^3 \text{ FOR SMALL } \alpha$$

$$R_{N/S} = \frac{\alpha_N^3}{\alpha_S^3 - \alpha_N^3} \approx 6.5$$

$$R_{N/S} = \frac{\alpha_N^3 - \alpha_S^3}{\alpha_S^3} \approx 0$$

Figure 2