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Section 7. Magnetospheric Radio Emissions

Routine observations of VLF/ELF emissions have been continued at our observatories, Moshiri and Kagoshima.

The data from our European VLF campaign are being analyzed. The interesting characteristics of frequency drift of mid-latitude VLF emissions at dawn sector,being associated with substorms, have been interpreted in terms of the velocity dispersion during the eastward longitudinal drift of energetic electrons after the injection around midnight. Then,we have found another kind of interesting VLF emissions in the premidnight sector,being again in close association with substorms. These premidnight emissions are characterized by their inverted V shaped frequency drift, which is interpreted by the combined effect of a cross-L drift and velocity dispersion. The VLF data at Moshiri during one solar cycle have been utilized to have further understanding of mid-latitude VLF emissions. Especially,the local time dependence and the association with geomagnetic disturbances have enabled us to estimate the resonant energies of electrons responsible for the generation of unstructured hiss and structured chorus. Further, the characteristics of VLF emissions triggered by whistlers observed at Moshiri are being studied.

Direction finding studies for magnetospheric plasma waves on board satellites have been continued. Wave normals of plasmaspheric ELF hiss observed on GEOS 1 have been determined, which has yielded that the waves are generated by large θ angles on a majority of cases. The generation of very oblique waves is consistent with the ground-based polarization measurement at Moshiri(L=1.6). Next,ELF hiss in a detached plasma region of the magnetosphere has been found to be nearly field-aligned, and then the occurrence of hiss in such detached plasma regions has been found to be satisfactorily interpreted in terms of quasi-linear electron cyclotron instability. Further study on the wave normal directions of chorus is being continued. A lot of attention has been paid to the study of half-gyrofrequency VLF emissions whose equatorial characteristics we have investigated previously. In order to obtain further

understanding on these waves, the direction findings have been made at off-equatorial regions of the magnetosphere. With the help of inverse ray-tracing,it is confirmed that the upper band VLF emissions are half-gyrofrequency VLF emissions which are generated, at the equator, at frequency above one half the gyrofrequency, with wave normals close to the oblique resonance cone. This has supported its generation by an electrostatic electron cyclotron instability we proposed. We are now studying the hiss-triggered chorus emissions observed on GEOS 1 near the equatorial region and in the off-equatorial region in order to study the wave-particle and triggering processes. Finally,the comparison of the merit and demerit of different direction finding methods (Means', least-squares method, maximum likelihood method and maximum entropy method) have been studied,with a special reference to their dependence on S/N ratio.

We have discovered an interesting phenomenon on Aureol 3 satellite; Doppler broadening of the transmission signals from Alpha VLF station,USSR and the associated sideband structures over Japan. Especially,those sideband structures have been confirmed, by means of the bicoherence analyses, to be resulted from the nonlinear coupling between VLF transmission signal and the existing ELF emissions. As an extension of this study, two collaborative works are being done. Firstly,we are carrying out the bispectrum analysis for the OMEGA VLF signals observed on ISIS satellite over Japan, this being done in collaboration with Radio Research Laboratory. Another international collaboration with Stanford University,Radio Research Laboratory and some others, has been successfully carried out during November 1987 to February 1988 in the Antarctic region; that is, VLF transmission signals from Siple Station are received onboard ISIS satellites in order to study the wave-particle and wave-wave interactions in the polar ionosphere. Recorded data will be analyzed shortly.

We have been continuing the study of wave-particle interactions at lower latitudes. The conjugate measurement of the reception of whistler-mode signals from the LF Decca stations in Hokkaido and Kyushu has been made at the conjugate point of each station in Australia in order to find out the latitudinal effect and the influence of different normalised frequencies. Theoretical study is also done on the nonlinear cyclotron interaction between LF waves and quasi-relativistic electrons in the inner radiation belt.

As for the forthcoming Japanese satellite experiments,we are responsible for the measurement of electric field by double probe method and so on, and we are engaged in designing the antennas,the associated

electronics to be installed on EXOS-D and GEOTAIL satellites. A new loop antenna system has been developed for EXOS-D,which detects electromagnetic waves in a wide band from 0.3 kHz up to about 1 MHz. A test experiment using this antenna system has been successfully made in the ionosphere onboard S-310-18 rocket. The conductive effect of the frame of EXOS-D flight model loop antenna has also been investigated. Then, the coupling network between the dipole antenna and the preamplifier to be used on EXOS-D,has been designed so as to measure the electric field from DC to higher frequencies. Finally,the preamplifier system for the sphere probe on GEOTAIL based on the floating-ground system is studied for the measurement from DC to VLF.

A monograph entitled,"Natural VLF radio waves" by Okada and Iwai, will be published,dealing with mainly the observational methods of VLF radio waves.

Prof.O.A.Molchanov,Chairman of VLF Department of IZMIRAN(Moscow, USSR) stayed with us for two months, October and November,1987 to have the general discussion on magnetospheric plasma waves and also to promote our collaboration. The important outputs from his stay are summarized as follows: (1) a new idea on the generation of plasmashpheric ELF hiss and (2) the agreement on the future collaboration on active experiment. As for the 1st subject,both of us have started elaborating our theory, and we will have more detailed discussion for the realization of our collaboration concerning the 2nd subject.

Messrs. M.Tian and C.C.Tang from Wuhan University,The People's Republic of China,worked with us for six months from December 1986 and they have learned our direction finding methods and their study was very useful for our following collaborative work. Based on the agreement with Space Physics Group,Wuhan University,in January 1988 we carried out the direction finding measurement for equatorial whistlers at three stations in China; Wuchang(geomag.lat. 19°), Guilin(15°) and Zhanjiang(10°), and the data are being analysed to study the propagation mechanism of equatorial whistlers and the plasma dynamics of equatorial ionosphere.

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