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Group 1.2 Magnetospheric Physics

Until March in 1988, Magnetospheric research related mainly to the generation and propagation of magnetospheric plasma waves had been reported by Section 4 (Whistlers and Related Phenomena) and Section 7 (Magnetospheric Radio Emissions). Since April in 1988, magnetospheric research has been continued in a reorganized sub-group, which is composed of three fewer researchers (Y. Tanaka, M. Hayakawa and M. Nishino). Also, the research field is required to include not only magnetospheric plasma waves but also the transfer and conversion mechanisms of energy and mass in the magnetosphere. Thus, our present research purposes are concerned with

1) Generation and propagation of magnetospheric plasma waves
2) Wave-particle and wave-wave interactions
3) Transfer and conversion mechanisms of solar energies in the magnetosphere.

Our recent research activities are based on the following experiments and data analyses.

1) Routine observations of VLF/ELF emissions
2) Conjugate measurements of LF, VLF and ELF, and ULF waves
3) Direction finding studies for magnetospheric plasma waves and wave-wave interactions, based on analyses of satellite wave data
4) Start of geomagnetism observations, and development of two-dimensional (image) riometer system

Routine observations of whistlers and VLF/ELF emissions have been continued by means of magnetic tape recording for two minutes every hour at our observatories, Moshiri ($L = 1.6$) and Kagoshima ($L = 1.2$). VLF/ELF emissions have also been observed, using valley antenna, and hiss type emissions are identified by means of hiss recorder.

The VLF data at Moshiri during one solar cycle have been utilized to obtain 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.

The data from our European VLF campaign are being analyzed. We have found interesting VLF emissions in the premidnight sector, 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. Further study on the frequency drift of VLF emissions has been done on the basis of the long-term data at Moshiri.

In order to clarify experimentally the propagation mechanism of magnetospheric plasma waves in the low-latitude magnetosphere and to study wave-particle interactions, conjugate measurements of LF and VLF transmitter signals, VLF emissions and ULF waves (magnetic pulsations) were made in Australia in 1984, 1986 and 1987.

A representative result obtained from the conjugate measurement of the reception of whistler-mode signals from a Decca station (Biei, $L = 1.54$, $85.725 kHz$) in Hokkaido is as follows. The whistler-mode signals usually revealed the frequency shifts: a dusk positive shift less then $0.5 Hz$ and a dawn negative shift more than $-0.5 Hz$. The Doppler shift may be caused by the combined effect of the electron density variation of a field-aligned whistler duct with downward (upward) electron flux and the drift of the whistler ducts due to westward (eastward) equatorial electric fields generated by an ionospheric dynamo process around sunset (sunrise), respectively. The occurrence of the whistler-mode signal indicates the highest correlation with the magnetic activity on one day prior to the occurrence. At magnetically severely disturbed times the whistler-mode signal was intensified by more than 20 dB, and it appeared almost continuously during the night. The positive frequency shift may be attributed to the drift of the whistler-ducts due to westward convective electric fields penetrating the low-latitude magnetosphere in association with magnetic disturbances.

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 wave normal angles in 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 of 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 a 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. Direction findings for chorus emissions in the off-equatorial region has been done, in order to discuss their generation mechanism.

The first attempt of spaced-direction finding measurements for equatorial whistlers at the three stations in South China have been carried out in January, 1988 in collaboration with the group of Wuhen University.

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, these 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 undertaken. 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 Communications Research Laboratory. Another international collaboration with Stanford University, Communications 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 on board ISIS satellites in order to study the wave-particle and wave-wave interactions in the polar ionosphere. Recorded data are under analysis.

We participated in the Global Auroral Dynamics Campaign (Coordinator, S. Kokubun, University of Tokyo) done in the summer of 1988 over a wide region centred at the central region of Canada. During the winter season of 1989-90 when the apogee of Exos–D satellite for direct investigations of auroral particle acceleration will come over the northern hemisphere, more coordinated and synthetic measurements of the related phenomena will be carried out in the northern polar region. For the campaign we are developing two-dimensional riometer systems for detecting auroral particle precipitation into the lower ionosphere. Moreover, measurements of geomagnetism and magnetic pulsation have been carried out at Moshiri and Kagoshima observatories.

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