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Group 1.2 Magnetospheric Physics

Since April in 1988, the magnetospheric research has been continued in the reorganized sub-group. As K. Yumoto removed to our group from Geophysical Institute, Tohoku University on April 1st, 1989, the present group is composed of four researchers (Y. Tanaka, M. Hayakawa, K. Yumoto and M. Nishino). The research field includes not only magnetospheric plasma waves but also the transfer and conversion mechanisms of energy and mass in the magnetosphere. Thus, our recent research activities are based on the following experiments and data analyses.

1) Routine observations of VLF/ELF emissions.
2) Observations of geomagnetism, ULF waves, low-latitude aurora and cosmic noise absorption (CNA).
3) Installation of two-dimensional (image) riometer system at a polar cap latitude, and coordinated observations of VLF & ULF waves at auroral latitudes.
4) Conjugate measurements of LF, VLF, ELF and ULF waves, and related satellite data analyses.
5) Direction finding studies for magnetospheric plasma waves, based on analyses of satellite wave data.

Routine observations of VLF/ELF emissions have been continued, using valley antennas at Moshiri (L = 1.6) and Kagoshima (1.2) observatories. Hiss type emissions are identified by means of the hiss recorder, and spectral data are obtained by magnetic tape recording for two minutes every hour. Moshiri observatory is located at higher latitude in Japan Islands, and is considered to be a key station at middle latitudes for synthetic observations concerning the Solar Terrestrial Physics. Whereas, Kagoshima is situated at lower latitudes and is important for the observations at a sub-tropical latitude. At Moshiri we have been installed a fluxgate magnetometer with 1 sec sampling rate, a scanning photometer with wave lengths of 427.8, 557.7, 630.0 and 668.3 nm, and a super wide auroral camera, since October 20, 1989. The observation of low-latitude aurora at Moshiri is a cooperative research programme with National Institute of Polar Research. A low-latitude aurora occurred in Hokkaido, Japan on October 21, 1989 after the lapse of 31 years. The photometer detected, fortunately, red aurora (630.0 nm) with the maximum intensity more than 15 kR

and the green component (557.7 nm) with the intensity more than 2 kR with a short duration in the most active phase of red aurora. Also, a riometer with widebeams at 30 and 60 MHz for CNA observation are operated, and a two-dimensional riometer system has being developed for preparing auroral particle detection at high latitudes. At Kagoshima, magnetic observations have been carried out by means of a fluxgate magnetometer and an induction magnetometer.

We participate in the Global Auroral Dynamics Campaign (Coordinator, Prof. S. Kokubun, the University of Tokyo) during 1988–90. In the winter season of 1989-90 when the apogee of the Exos–D satellite for direct investigations of auroral particle acceleration comes over the northern hemisphere, coordinated, simultaneous observations of the related phenomena have been carried out in the northern polar region. Also, this campaign will be coordinated with a rocket launching around February 20, 1990 at Andoya, Norway, by ISAS. The image riometer system has been continuously operated since September, 1989 at Ny-Alesund (L = 16.5), Svalbard, in cooperation with Department of Physics, University of Oslo, and Norwegian Polar Research Institute.

In order to experimentally clarify the propagation mechanism of magnetospheric plasma waves and wave-particle interactions in the low-latitude magnetosphere, and to study the energy transfer mechanism, conjugate measurements of LF and VLF transmitter signals, VLF emissions and ULF waves(magnetic pulsations) were made in Australia in 1984 and 1986. Furthermore, coordinated observations are being planned for 1990-91, along the magnetic meridional plane centred at a magnetic conjugate pair: Moshiri, Japan, and Birdsville, Australia, which could lead to more coordinated world-wide ground-based observations for an International Scientific Programme "Solar Terrestrial Energy Programme" during 1991–96. Representative results from the conjugate measurements and analyses of related satellite data are such as:

Energetic electrons measured by the NOAA–6 satellite are compared with LF whistler-mode signals transmitted from a Decca station (Biei, L = 1.54, fc = 85.725 kHz), in Japan and measured in magnetic conjugate area, Australia. The simultaneous satellite measurement of energetic electrons indicated a considerable enhancement of energetic electron fluxes more than 30 keV in the low L shell region below 2 at the maximum depression phase of Dst, and ubsequent abundant fluxes of trapped electrons more than 30 keV on one day and occasionally two days after the maximum phase. Associated with magnetic disturbances, the LF whistler-mode signals were intensified. The medium or faint intensity increase of the signals at the maximum phase may be attributable to an ineffective wave growth caused by a rather isotropic pitch angle distribution of energetic electrons. Whereas, the large intensity increase on one day after the maximum phase may be due to wave growth caused by cyclotron resonance interactions with trapped electrons. Also, associated with magnetic disturbances, the frequency of enhanced LF whistler-mode signals shifted, which is caused by the drift of whistler ducts due to the magnetospheric electric fields penetrating

into the low-latitude magnetosphere.

The relation between Pi 1–2 pulsations on the ground and substormassociated magnetic field variations in space has been studied using the data obtained on the ground at low-latitude conjugate stations (L = 1.3 – 2.1) and in the near-Earth magnetotail by the AMPTE CCE spacecraft. Hydromagnetic disturbances can be interpreted to be launched at the time of field dipolarization in the reconnection (or current disruption) region in the near-Earth tail during the substorm expansion phase. Field line resonance driven by a quasi-monochromatic oscillation in the near-Earth tail is the cause of the Pi 1 pulsations observed on the ground. A portion of the disturbances can propagate along the field line in the Alfven mode to the high-latitude ionosphere, and contribute to a localized high-latitude Pi 2 pulsation on the nightside. On the other hand, the compressional impulsive signals with a broad-band frequency can propagate across the ambient magnetic field into the dayside magnetosphere, and excite a cavity resonance mode in the whole inner region bounded by the plasma sheet. The magnetospheric cavity resonance wave further couples into a global field line oscillation with a discrete frequency, which can be observed as a global Pi 2 pulsation at world-widely separeted ground stations.

The conjugate experiment was conducted in August, 1989 in collaboration with IZMIRAN and the University of Otago. The Soviet group sent special pulse trains of the Alpha transmission at 15 and 23.9 kHz, and we operated, at its conjugate point, Ceduna, Australia, VLF receivers for both the subionospheric and magnetospheric signals from the transmitter. The associated particle precipitation was measured by the Otago group at Ceduna by means of the riometer and NWC signal perturbation. The data are being analyzed for detailed quantitative study of wave-particle interactions at lower latitudes.

Direction finding studies for magnetospheric plasma waves on board satellites have been continued. The wave normal directions of chorus emissions in the off-equatorial region of the outer magnetosphere have been determined on board GEOS 1 satellite, and based on those direction finding results, the generation and propagation mechanisms of chorus have been studied. In order to obtain further understanding of half-gyrofrequency VLF emissions, 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 a frequency above one half the gyrofrequency at the equator by an electrostatic electron cyclotron instability, with wave normals close to the oblique resonance cone. The hiss-triggered chorus emissions observed on GEOS 1 near the equatorial region and in the off-equatorial region are being studied in order to identify the wave-particle and triggering processes. And the comparison of the merit and demerit of different direction finding methods (Means', leastsquares method, maximum likelihood method and maximum entropy method) has been made with a special reference to their dependence on S/N ratio.

The first attempt of spaced direction finding measurements for equatorial whistlers at the three stations in South China has been carried out in January, 1988 in collaboration with Wuhen University. It is found that characteristics such as the ionospheric exit regions, dispersion, echo-train whistlers etc are more likely to be attributed to field-aligned propagation rather than non-ducted propagation.

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- Yoshihito TANAKA -

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