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Independent Component Analysis of Nightside Magnetospheric Forced Pi 2 Oscillations Observed at the CPMN Stations

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From the long-term accumulation of the observational facts, low-latitude Pi 2 pulsations observed at different latitudes and longitudes with a common waveform and frequency (e.g., Yumoto, 1986). Moreover, from a ground-satellite statistical study by Takahashi et al., (1995), it is found that Pi 2 pulsations inside a region of +-3 hours of local midnight in the inner (L=2-5) magnetosphere are dominated by the poloidal components, that is, fast-mode waves polarized in the meridian plane. The spatial phase structure support cavity-mode-type resonance excited between two reflecting boundaries. Based on these facts, it has been thought that the plasmaspheric cavity resonance is most likely mechanism for low-latitude Pi 2 pulsations observed on the ground.

On the other hand, high-latitude Pi 2 pulsations consist of different mode oscillations. At high latitudes, the magnetic variations during substorm onset are believed to consist of Pi 2 component and ionospheric and field-aligned current fluctuations. That is, Pi 2 pulsations observed on the ground are a superposition of several different modal components. However, since the realistic mixing system of magnetosphere is unclear, it is difficult to understand the spatial distribution of Pi 2 pulsations observed on the ground. In particular, the relationship of high- and low-latitude Pi 2 pulsations have been unsolved issue. We therefore need some new methods that make it possible to separate such mixed signals as Pi 2 pulsations observed on the ground and classify them objectively and quantitatively by their modal characteristics.

To achieve that, we have experimented an application of Independent Component Analysis (ICA) to Pi 2 pulsations observed at the CPMN (Circum-pan Pacific Magnetometer Network) stations. ICA is one of the multi-dimensional variable techniques based on statistically independence. It started to be used in 1990s in the field of signal processing (e.g., Jutten and Herault, 1988). It has been successful in resolving observed mixed signals including brain imaging data and voice signals into source signals.

As an initial stage of this study, we applied the ICA to analyze Pi 2 pulsations observed globally at the CPMN (Cir-cum Pan Magnetometer Network) stations during 13:30-14:00UT on February 17, 1995. As a result, we found that Pi 2 pulsations observed on the ground mainly consist of two components. One was the global cavity-like oscillation observed from high latitudes to equatorial latitudes on the nightside and dayside with the same waveform and frequency. Their amplitudes were largest at TIK (mlat=65.65, mlon=196.90, L=5.98)). In addition, they had a phase reversal near plasmapause and phase shift between TIK and CHD (mlat=64.66, mlon=212.14, L=5.55), which are longitudinally separated stations at high latitudes. This result cannot be explained by existing plasmaspheric cavity resonance model. Thus, we have decided to call this Pi 2 component 'a nightside-magnetospheric forced oscillation' by means of 'a cavity-like oscillation' or 'a global cavity mode'. Another component was localized fluctuations at high-latitudes. Hence, they were most likely caused by some local phenomena in auroral region such as westward auroral electrojets and/or oscillations of current wedge.

As a second stage of this research, we have focued on the 'nightside magnetospheric forced Pi 2 oscillations' and statistically analyzed them to clarify their generation and propagation mechanisms by means of the ICA.