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Calibration of the KAGUYA/WFC data for AKR polarization analysis

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The KAGUYA spacecraft frequently observed auroral kilometric radiations (AKR) which were originated from the Earth's auroral region. It is well-known that the AKR is dominated by right-handed (R-X) mode wave with small contribution of left-handed (L-O) one. Observation probability for magnetic local time and latitude, intensity, frequency range depend on the polarizations. The KAGUYA mission gave a good opportunity to make a stochastic analysis of such dependences from lunar orbits.

The WFC was a plasma wave receiver onboard the KAGUYA spacecraft. The frequency sweep receiver WFC-H, which was a subsystem of the WFC, continuously observed power spectrum and polarizations of waves in a frequency range from 1 kHz to 1 MHz during the whole mission period. However, there is a serious problem in the obtained polarization data. Because of differences of onboard-processing timings between two orthogonal antennas X and Y, the polarization data cannot be used at all. In the present study, we develop a calibration method on these data to derive exact AKR polarizations.

The processing time lag between X-Ych was caused by asynchronous operation of two onboard ICs called PDCs (programmable down converters) which were assigned to X-Ych signals, respectively. The role of the PDCs is to divide the frequency range from 1 kHz to 1 MHz into 26 narrow bands.

In order to estimate the time (phase) differences between X-Ych signals in these bands, we used overlapped-frequency range data in the adjacent two bands. We statistically calculated differences of the "XY phase difference" in the adjacent two bands. As a result, the differences had linear property for frequency, which means that the time lags between X-Ych are constant in all the 26 narrow bands. The delay time of Ych signal to Xch one is 1.1 microseconds. We also estimated time delays of three low pass filters in the PDC in each narrow band. According to these results, all the WFC-H polarization data can be calibrated.

Before calibration, the polarization depends on only the frequency. This result seems strange because the AKR polarization is stable for frequency in principle. After calibration, on the other hand, the polarization depends only on time and exhibits a 2-hour periodicity. This result is reasonable because the arrival direction of the AKR varies depending on the satellite attitude. Using the calibrated data, we obtained the AKR polarizations for ambient magnetic field. It is possible to study the AKR polarizations propagating from the northern and southern hemispheres independently using the occultation of the Moon.

Keywords: KAGUYA, AKR, calibration