Far-sidelobe and Polarization Measurement of LiteBIRD Low Frequency Telescope using a 1/4-scaled Model

(1/4 スケールモデルを用いた LiteBIRD 低周波望遠鏡の広角サイドローブと偏光特性の測定)

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Polarization of the Cosmic Microwave Background (CMB) has crucial information on the inflationary universe. To detect these signals, we need a telescope with a broad frequency coverage and a wide field of view. On the other hand, development of such a telescope has difficulties in the calibration of far-sidelobes and polarization angles. Far-sidelobes contaminate the weak CMB polarization signals with strong radiation from the Galactic plane coming outside of the pointing direction. Errors of the polarization angles result in generation of pseud polarization.

LiteBIRD is the only funded CMB observation satellite for the 2020s, and the Low Frequency Telescope (LFT; 34–161 GHz) is one of its telescopes. To verify its optical design, we carried out near-field antenna pattern measurement of a 1/4-scaled LFT at scaled frequencies between 140–220 GHz, which correspond to the lowest bands of the full-scale LFT. We investigated the antenna patterns up to 60° from the boresight, not only at the center but also at the edges of the focal plane to cover the 20° field of view. The measurements were consistent with simulated far-sidelobe patterns down to -50 dB level, and indicated that far-sidelobes for two orthogonal polarization directions are consistent with each other down to -40 dB level. We also measured the cross-polarization patterns and confirmed that their peak levels are less than -20 dB, most of which originate from the feed.

On the other hand, near-field measurement takes impractically long time at higher frequencies and for polarization angle measurement. Therefore, we developed another measurement system with compact antenna test range method. Because the ground calibration of the LFT is planned to be conducted at its operation temperature of 5 K, we designed the setup as small as possible to implement in a cryogenic chambers. The measured antenna patterns are consistent with those measured by near-field measurement down to -40 dB level. We also measured the polarization angles with wire grid polarizers and a goniometer stage. The measurements were well explained by a simple Jones calculus, and the statistical error of the determined polarization angles was less than ± 5 arcsec.