Abstract

The primordial gravitational waves predicted by inflation theory are expected to have produced a unique polarization pattern, called B-modes, in the polarization component of the Cosmic Microwave Background (CMB) radiation. In order to observe these weak signals with high precision, we need a telescope with high throughput and a large diffraction-limited field-of-view. Such a telescope also requires a low-noise detector array at its focal plane that is operated at cryogenic temperatures. A crossed-Dragone telescope is an advantageous optical system for wide field-of-view (FoV) telescopes, but can be prone to stray light systematics, which can contaminate the CMB signal with radiation from the Galactic plane. Such stray light systematics appear as far-sidelobes of the telescope antenna pattern, and therefore we need to accurately characterize the telescope's sidelobe patterns.

LiteBIRD is a satellite mission to investigate the CMB polarization, and the Low Frequency Telescope (LFT; 34 – 161 GHz) is one of telescopes. The LFT is a crossed- Dragone telescope with 400 mm aperture diameter and the FoV is 18° × 9°. The LFT has 1080 transition edge sensors on the focal plane. The required far sidelobes knowledge is −56 dB.

The antenna patterns of the LFT have been characterized with a 1/4-scaled antenna of the LFT and a heterodyne receiver using vector near-field measurement, which directly measure the complex electric fields near the aperture by a millimeter-wave vector network analyzer.

In this study, we present a holographic phase-retrieval method that enables near-field measurements using telescope-equipped bolometric detector array as it is. We place a reference emitter at a fixed position and scan a signal emitter at the telescope aperture. These two emitters are phase-locked and generates interference patterns (holograms) on the focal plane, from which the amplitude and phase of the aperture field can be retrieved. We measured antenna patterns of LFT 1/4-scaled antenna for the three different focal positions at 180 GHz (corresponding to 45 GHz in the real-scale). Antenna patterns derived from the phase retrieval measurements are consistent with those from the vector near field measurements at the sidelobe level of -60 dB for the center and edges of the focal plane. We also measured the cross polarization pattern for the center of the focal plane, and confirmed that it is also consistent at the sidelobe level of -60 dB.