Requirement analysis for LiteBIRD's optical system

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Abstract

LiteBIRD is a science satellite project being prepared as the second ISAS strategic large mission. We plan to make a full-sky map of the microwave background polarization by scan observation at millimeter wavelengths. By extracting odd-parity components from the polarization map, we expect to detect a primordial gravitational wave background signal from cosmic inflation in the early universe. Compared with the signal originating from the primordial density fluctuations, we expect that the signal from the primordial gravitational waves is much fainter. Therefore, it is an urgent task to clarify instrumental characteristics and their associated systematic errors.

In 2022, we started to study about leakage of diffracted sunlight. Using a simulation model of Low-Frequency-Telescope (LFT), in the evaluation of which we considered the spatial configuration surrounding the telescope, we worked on quantifying the sunlight leakage. We have already completed preliminary runs and plan to progress in memory saving and multi-threading of the program to prepare for actual computations. Besides the above activity, we collected samples of microwave background polarization skies. With such many sky maps, evaluating statistical uncertainty originating from systematic biases will be possible.

Ref. URL: https://litebird.isas.jaxa.jp/static/eng/

Reasons and benefits of using JAXA Supercomputer System

LiteBIRD is a project to make a full-sky map of the microwave background polarization by scan observation. In this research, we perform an entire suite of data analysis simulations from numerically generating time-ordered data to map reconstruction. Mock data samples to each of which an integration operation for beam convolution is applied are generated at 19 Hz for three years in the simulations. Beam functions are evaluated on several million grid points at every sampling occasion. Since repeating a coordinate transformation for mapping beam properties to points on the celestial sphere requires much computational complexity, we need a highly integrated computing resource. The outcomes of this research are counted as bases of optics design in the LiteBIRD project, which is the second ISAS strategic large mission.

Achievements of the Year

The adopted simulation model of the LFT optics includes a baffle and a radiative cooling system (V-groove) surrounding the mission instruments, allowing for the evaluation of the diffraction effects of sunlight propagating from the telescope side. Figure 1 shows the beam pattern at 34 GHz of a detector located at the focal plane edge, which we used in our preliminary run. V-groove significantly suppresses the beam's amplitude in the region shielded by the V-groove, but still, we observe a response of around -90 dB near a 90-degree angle. Since 34 GHz belongs to the frequency band where synchrotron emission dominates, we plan to perform simulations in ~100 GHz, the frequency band of the microwave background radiation, to quantify the effects of diffracted sunlight.

In addition to these activities, we collected samples of microwave background polarization skies. We have prepared approximately ten thousand samples reflecting non-linearity, such as gravitational lensing effects, not just making Gaussian fields. We expect that, in the future, we can identify the statistical uncertainties of observables that vary due to various systematic biases using simulations.

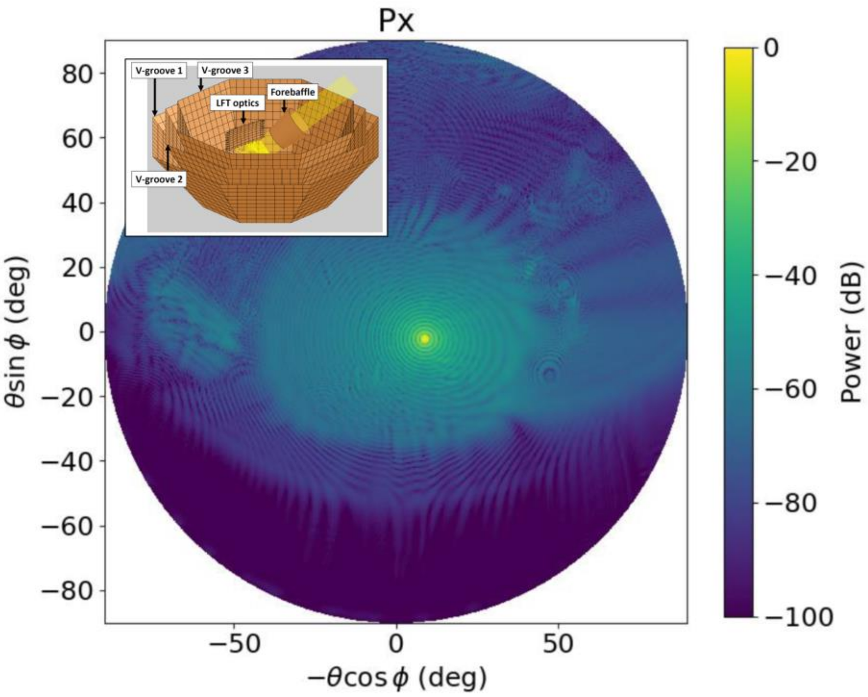

Fig. 1: 34 GHz beam pattern of a detector located at the edge of the LiteBIRD LFT focal plane, which is evaluated by considering the spatial configuration surrounding the telescope (top-left window) : F.T.Matsuda et al, The 23rd Space Science Symposium (2023)

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	N/A
Number of Processes	108
Elapsed Time per Case	2 Hour(s)

JSS3 Resources Used

Fraction of Usage in Total Resources*1(%): 0.00

Details

Computational Resources		
System Name	CPU Resources Used (core x hours)	Fraction of Usage*2(%)
TOKI-SORA	54,781.12	0.00
TOKI-ST	1,159.52	0.00
TOKI-GP	0.00	0.00
TOKI-XM	0.00	0.00
TOKI-LM	74.03	0.00
TOKI-TST	0.00	0.00
TOKI-TGP	0.00	0.00
TOKI-TLM	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2] (%)
/home	3.33	0.00
/data and /data2	6,766.67	0.05
/ssd	33.33	0.00

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage[*2] (%)
J-SPACE	0.09	0.00

[*1]: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.

- **ISV Software Licenses Used**

ISV Software Licenses Resources		
	ISV Software Licenses Used (Hours)	Fraction of Usage[*2] (%)
ISV Software Licenses (Total)	0.00	0.00

[*2]: Fraction of Usage：Percentage of usage relative to each resource used in one year.