CMB Polarization Experiment “GroundBIRD”

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Cosmic microwave background radiation (CMB) is the oldest electromagnetic radiation we can observe in the universe. The observations of its 2.7 K blackbody spectrum and its anisotropy strongly support the Big Bang cosmology, and also strongly imply the “inflation” before the bang. In order to prove its presence, the best way is to find the sign of the primordial gravitational waves. The waves are expected to imprint the rotational polarization patterns named “B-mode” on the CMB.The precise measurement of the spatial spectrum of the polarization distribution is strongly required. For this purpose, we are developing the ground-based experiment, GroundBIRD. The telescope is planned to be situated in Canary Islands and its operation will start in 2017. In this presentation, we will show the current status of the development.

GroundBIRD introduces several keytechnologies to realize the low detection limit for the CMB polarization observations such asa high-speed rotatingtelescope, cooled optics, and microwave kinetic inductance detectors (MKIDs). The high-speed rotating telescope is realized by amechanical cryostat on a rotating table. We have newly developed a rotary jointto pass through the high-pressure helium gas as well as the electrical lines.The joint enables usto connect the head of the cryostat to the compressor placed on the ground. By combining the mechanical cooler with a ^{3}He depressurized stage (He-10), we have achieved the temperature of 0.23 K with a holding time of more than 24 hrswith the continuous rotation at 20 rpm.The rotation enables us to scan a wide range of sky continuously and repeatedly. The expectedmultipolecoverageis 6 $< l <$ 300. The rotation is also advantageous to reduce the $1/f$ noise of the atmospheric perturbation.

We have adopted a cold optics below 4K tosuppress the radiation noise. The size of the aperture window is 30 cm in diameter. To minimize theincident thermal radiation, the metal-meshed filters (QMC Instruments Ltd.) and the radio-transform multi-layer insulations (RT-MLI) areutilized. The latter consists of a set of stacked formed-polystyrene layers. Each layeris transparent to radio waves andopaque to infrared radiation. Because the RT-MLIis cooleddown by itself by radiating heat, no thermal link is required.Its performance does not change even if the aperture size changes. We have achievedthe mirror temperature at 3.4 K andthe cold stage at 0.21 K.

As the focal plane detector, we have adopted MKIDsbecause of its fast response time (~100 μs),a large number of pixels, and high sensitivity. The fast time response is crucial for the high-speed scanning observations. The readout of MKIDsis based on the frequency domain multiplexing, and it enable us to realize a large-format detector array.The number of pixels is 109 and 330 pixels at 220and 145 GHz, respectively.