

Calibration of detector time constant with a thermal source for the POLARBEAR-2A CMB polarization experiment

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The Simons Array (SA) project is a ground-based Cosmic Microwave Background (CMB) polarization experiment in Atacama, Chile, at 5,200 m. The objective is to characterize the B-mode signals from inflationary gravitational waves and gravitational lensing effects. The SA observes the sky with three telescopes, and POLARBEAR-2A (PB-2A) is the receiver system on the first telescope. The projected constraint on a tensor-to-scalar ratio r is at a level of $\sigma(r) = 0.006$, and the sensitivity to the sum of neutrino masses is 40 meV (68% C.L.).

Because the B-mode signal is weak, it is essential to control various systematic effects. Atmospheric fluctuation is the primary systematic source for the ground-based experiment, which causes significant polarization leakage. In the PB-2A receiver system, a continuously rotating Half Wave Plate (HWP) is used to mitigate the systematic error. The uncertainty in the time constant of the detector with respect to the rotational speed of the HWP results in an uncertainty in the polarization angle. For the PB-2A, the time constant of each bolometer needs to be calibrated at a sub-millisecond level not to introduce the bias to the B-mode signal.

We have developed a new calibrator system, which we can use to calibrate the time constants of the detectors. The calibrator system has a chopped thermal source (1000K), where a ceramic heater is used as a black body radiator covering up observation frequency bands, 90 GHz and 150 GHz. The radiation from this system covers the entire focal plane. The responsivities and time constants of the detectors are measured by tracking their optical responses over a range of chopper frequencies.

The calibrator was constructed and installed in late 2018 in the PB-2A, and has been working for more than three years at the observing site. We present the design consideration of the calibration system, the basic performance of the system, and preliminary results of the time constant calibration for the PB-2A Transition Edge Sensor (TES) bolometer array.