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Drone-based polarization calibration source for mm-wave telescopes

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Experiments to measure the polarization of the CMB require an exquisite characterization and control of optical systematics to achieve their scientific goals. Relevant parameters are the polarized co- and cross-polar beam shape, absolute and relative polarization angle among detector pairs, polarization frequency dependence across the bandpass, and polarization properties of far sidelobes. In particular, the absolute polarization angle is important to detect cosmic birefringence and test alternative cosmological models. Unfortunately, there are only very few natural polarized sources that can be used to characterize and calibrate the polarized response of these telescopes, for which an artificial source becomes an appealing alternative. Using a ground based artificial source is usually incompatible with CMB telescopes because the resulting low elevation angle implies strong ground temperature contamination. Here we present the development of a polarized calibration source that can be mounted on a drone to illuminate telescopes at a distance and away from the ground loading. We have already shown that it is possible to lift a 4 kg payload at 5200 meters, in 10 minute flights, reaching the far-field of small aperture telescopes and entering the Fresnel regime for larger aperture telescopes. We implemented a 150 GHz coherent source, with a single selectable linear polarization, fixed frequency and electronic chopper at 10 Hz. The position of the source with respect to the telescope is measured in time to better than 2 cm precision, and angles better than 0.05 degrees, using a combined method based on differential GPS and optical photogrammetry. This allows us to match and synchronize the telescope's raw detector time streams to the source position and polarization angle in order to compensate the drone's movements. This source can be used to measure the polarized beam shape, relative and absolute polarization angles and map far sidelobes. We have performed the first successful measurements of polarized far sidelobes of the ACT telescopes in Cerro Toco, and the results will be included in this presentation.

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