Small Aperture Telescopes for the Simons Observatory

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Abstract

The Simons Observatory (SO) is an upcoming cosmic microwave background (CMB) experiment located on Cerro Toco, Chile, that will map the microwave sky in temperature and polarization in six frequency bands spanning 27 to 280 GHz with first light planned for 2021. SO will consist of one 6-meter Large Aperture Telescope (LAT) fielding approximately 30,000 detectors along with an array of three 0.5-meter Small Aperture Telescopes (SATs) fielding another 30,000 detectors. This synergistic combination will allow for extremely sensitive characterization of the CMB over angular scales ranging from an arcmin to tens of degrees, enabling a wide range of scientific output. Here we focus on the SAT program targeting large angular scales from \( 10\% \) of the sky with successive dichroic instruments observing at Mid-Frequency (MF: 93 and 145 GHz), Ultra-High-Frequency (UHF: 225 and 280 GHz), and Low-Frequency (LF: 27 and 39 GHz). This configuration will enable maps of white noise level \( = 2 \mu \text{arcmin} \) in combined 93 and 145 GHz bands, and characterization of the CMB as well as galactic foregrounds (primarily dust and synchrotron), with a primary science goal of characterizing the primordial tensor-to-scalar ratio, \( r \), at a target level of \( \sigma(r) = 0.003 \).

Simons Observatory Overview

Large Aperture Telescope

- 6 m Cross-Dragone Telescope
- Az-Ei telescope with receiver co-rotator
- 2.4 m diameter cryostat receiver with 7x 38cm optics tubes (upgradable to 13x)
- 30,000+ detectors at 100 mK

Small Aperture Telescope Array

- 3x 42cm Refractive Telescopes
- Individual 3-axis (Az-Ei-Bore sight) mounting
- Polarization Modulation via Continuously rotating Cryogenic-Half-Wave-Plate (CHWP)
- 30,000+ detectors at 100 mK

Figure: Preliminary Site Location. SO will be located in the extreme-elly and Atacama Desert, at an elevation of 5190 m on the Cerro Toco mountain in the Chilien Andes. The Observatory will immediately neighbor the existing ACT, Simons Array (SA), and CLASS CMB experimen-tals, and closely neighbor the Atacama Large Millimeter Array (ALMA) and the upcoming CAt-prime radio telescopes, enabling SO to produce a scientific program with rich complimentarity with existing and upcoming data sets.

Key Features Common to Both

- Combination of Lenslet-Coupled Sinuous Detectors and Horn-Coupled OMT Detector Wafers
- 3 flavors of Dichroic TES Detectors: LF 30/40 GHz, MF 90/150 GHz, HF 220/270 GHz
- Broad frequency coverage enables robust spectral separation of CMB from foregrounds
- Detectors Readout with Frequency-Domain Microwave SQUID Multiplexing (\( \mu \)Max)
- High-Dry Site in Parque Astronomico Atacama, Chile (elevation: 5200 m) + Shared Infrastructure
- Technology, Analysis, and Science Expertise of Entire Simons Observatory Collaboration

Left: Spline feed coupled ortho-mode transducer detectors (fab by NIST). Right: Lenslet coupled sin-uous antenna detectors (fab by Berkeley). Both are coupled to Transition Edge Sensor Bolometers

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\[ \sigma(\mu) = 0.003. \]