The Atacama B-mode Search Status and Prospect

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Akito Kusaka (Princeton University) for ABS Collaboration
Before starting my talk...

Atmosphere is unpolarized
ABS (Atacama B-mode Search)

Princeton, Johns Hopkins, NIST, UBC, U. Chile
What is ABS?

- Ground based
- CMB polarization (with T sensitivity)
- Angular scale: $l \sim 100 (~2^\circ)$, B-mode from GW
- TES bolometer at 150 GHz
  - 240 pixel / 480 bolometers
  - ~80% of channels are regularly functional
  - NEQ ~ 30 $\mu$K$\sqrt{s}$ (w/ dead channels, pol. efficiency included)
- Unique Systematic error mitigation
  - Cold optics
  - Continuously rotating half-wave plate
Site

- Chile, Cerro Toco
  - ~5150 m.
  - Extremely low moisture
  - Year-round access
  - Observing throughout the year
  - And day and night
Possible combined analysis among CMB experiments

Cerro Toco 5600 m

Cerro Chajnantor 5612 m

ACT, ABS, PolarBear, CLASS (5150 m)

TAO, CCAT

APEX

QUIET, CBI

ALMA (5050 m)

ASTE & NANTEN2 (4800 m)
ABS instrument

Many figures / pictures are from theses of T. Essinger-Hileman and J. W. Appel (+ K. Visnjic and L. P. Parker soon)
Optics

4 K cooled side-fed Dragone dual reflector. ~60 cm diameter mirrors. 25 cm aperture diameter.
Optics

- The optics maximize throughput for small aperture
- 12° radius field of view
- Good image quality across the wide field of view
ABS focal plane

Feedhorn coupled
Polarization sensitive TES

Omit
Inline filter
Ex TES
Ey TES

1.6 mm
5 mm

Fabricated at NIST

Focal plane ~300 mK

~30 cm
Focal Plane Elements

Individually machined corrugated feedhorn
Compact & modularized focal plane unit of 10 pixels (20 TES + 2 dark SQUID ch.)
Continuously rotating warm half-wave plate

A-cut sapphire (D=330 mm)

\( f \sim 2.5 \text{ Hz rotation} \rightarrow f \sim 10 \text{ Hz modulation} \)

Air-bearing \( \rightarrow \) Stable rotation

No need for pair differencing
Observing and Data
Fields Observed by ABS

Low foreground region selected

Field A: primary CMB field, ~2300 deg.$^2$
Field B: secondary CMB field, ~700 deg.$^2$
Observing cycle

- 48-hour fridge cycle (~7 hours for He recycle)
- $41/48 = 85\%$ observation
  - $\approx 61\%$ at CMB field A
  - $\approx 27\%$ at CMB field B
  - $\approx 10\%$ at calibration and galactic center
Calibration strategy

- **Responsivity**
  - Sources: Jupiter, Venus, TauA, RCW38
  - Skydip
  - Wiregrid

- **Polarization angle**
  - Wiregrid, TauA

- **Pointing, Beam: sources**

- **Detector response**
  - Wiregrid+HWP, chopper
Wiregrid
Wiregrid

Phase rotation measured by varying HWP frequency

S. M. Simon
(see her poster at LTD15)
There is a “constant” HWP signal structure

- 2\(\phi\) component dominates
- Small 4\(\phi\) component
  - This is constant at the first order
- These can be used as calibration
HWP structure vs. pwv

2φ component >> 4φ component
2φ component tends to be proportional to intensity input
4φ component has less dependence on the intensity
Demodulated timestream

Right: TOD power spectrum

Bottom: knee frequency distribution from 1 week of data

Study under way: it can be better.
Impact of HWP performance

Gravity wave B-mode signal

ACT data (temperature)

Loss in low-l experiments is significant
@ lowest bin
60% loss in QUIET (2012)
70% loss in BICEP1, Chiang et. al. (2012)

ABS may gain back sizeable portion

Fowler et. al. (2010)
See also Pryke et. al. (2009)
Impact of HWP performance

- Extremely good rejection of spurious polarization
- Most of the channels I→Q/U leakage well below 0.1%
  - Cf. BICEP1~1%, QUIET - W~0.2%
- Well controlled systematic error from CMB ΔT and foregrounds
  - In “optimistic” dust model, dust ΔT+leakage may be dominant
Summary

- **ABS**
  - 480 TES + unique systematic mitigation
  - In particular, warm continuously rotating HWP opens a very interesting phase space in experimental configuration

- **Status**
  - Observing!!