The Arcminute Cosmology Bolometer Array Receiver

W.L. Holzapfel*[1], P.A.R. Ade[2], R.S. Bhatia[3], J.J. Bock[4], M.D. Daub[1], J.H. Goldstein[5], C.L. Kuo[1,6], A.E. Lange[7], M. Lueker[1], M. Newcomb[1], J.B. Peterson[8], J. Ruhl[9], E. Torbet[5], D. Woolsey[1]

[1]Department of Physics, University of California at Berkeley, Berkeley, CA 94720
[2]Department of Physics and Astronomy, Cardiff University, CF24 3YB Wales, UK
[3]European Space Agency, 2200 AG Noordwijk, The Netherlands
[4]Jet Propulsion Laboratory, Pasadena, CA 91125
[5]Department of Physics, University of California, Santa Barbara, CA 93106
[6]Department of Astronomy, University of California at Berkeley, Berkeley, CA 94720
[7]Department of Physics, Math, and Astronomy, California Institute of Technology, Pasadena, CA 91125
[8]Department of Physics, Carnegie Mellon University, Pittsburgh, PA 15213
[9]Department of Physics, Case Western Reserve University, Cleveland, OH 44106

The Arcminute Cosmology Bolometer Array Receiver (ACBAR) is a novel instrument designed specifically for observations of fine scale cosmic microwave background (CMB) anisotropy and the Sunyaev-Zel'dovich effect. The instrument is a 16 element 230 mK bolometer array that is presently being used to produce images the CMB in three millimeter wavelength bands with approximately $4'$ resolution.

The receiver is designed to observe from the 2.1 meter off-axis Viper telescope located at the South Pole. A chopping tertiary mirror sweeps the 16 ACBAR beams 3 degrees across the sky in a fraction of a second without introducing excessive modulated telescope emission or ground radiation pickup. The signals produced as the beams sweep across the sky correspond to sensitive measurements of differences in the sky temperature. The large chop of Viper results in high resolution ($\Delta\ell \sim 120$) measurements of the recovered power spectrum over the range from $\ell \sim 120 - 3000$.

Under the low background conditions available at the South Pole, the ACBAR detectors become background limited at a temperature of approximately 300 mK. The noise equivalent temperature of the 2.1 mm wavelength detectors is measured to be $300\,\mu\mathrm{K}\sqrt{s}$. ACBAR makes use of a self-contained 3-stage Helium sorption refrigerator to reach a temperate of 230 mK with a hold time of 36 Hours. The fridge is periodically recycled with an automated system resulting in a duty cycle of $\sim 90\%$.

The ACBAR frequency bands are optimized to achieve maximum signal to noise while observing the SZ effect and CMB anisotropies in the presence of atmospheric emission. We use a combination of black polyethylene, Yoshinaga, Pyrex, and resonant mesh filters to precisely define the passbands and block high frequency leaks. The band averaged optical efficiencies for the 2.1, 1.4, and 1.1 mm passbands range from $31 - 40\%$.

ACBAR was deployed to the South Pole in December 2000 at has operated continuously for the past two years. The deepest ACBAR observation has produced a 6 deg^2 map with a RMS noise in a $4'$ pixel of $\sim 10\,\mu$K at 150 GHz and $25\,\mu$K at 220 GHz. This is the most sensitive image of the CMB produced to date and has been used to determine the power spectrum of the fine angular scale CMB with unprecedented accuracy. We have also produced images of the Sunyaev-Zel'dovich effect in a sample of low redshift clusters of galaxies and performed a search for distant unknown clusters. ACBAR is presently being prepared for a third season of winter observations.