COSMIC MICROWAVE BACKGROUND STUDENT LABORATORY

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We will review an undergraduate laboratory to detect and measure the temperature of the Cosmic Microwave Background (CMB) radiation. The lab was developed at the University of Chicago by the author while teaching an undergraduate special topics course on Radio Astronomy. It is now routinely conducted in the core curriculum for both science and non-science majors and as a result is performed by all freshman at the University. It is also conducted at adult education and other outreach events. The laboratory is based on a cooled, low-noise, HEMT receiver operating at 30 GHz with a $\sim$ 10 degree beam. The students measure the receiver and the sky temperature as a function of airmass and then extrapolate to zero airmass. The excess noise found at zero airmass is assumed to be the CMB background. In good weather conditions the results are accurate to about 0.5 K. The laboratory effectively reproduces the Penzias and Wilson CMB detection. The experiment purposedly is not automated; the students hold up the calibration loads, monitoring their temperatures with laboratory thermometers. They record all the data in their lab books. They also insert and remove a large reflective cone that acts like a ground screen. Through conducting several consistency checks as they conduct the experiment, the students learn how real experiments work and in particular how to know what data to trust. The students actually enjoy the laboratory and are excited to have detected 14 billion year old radiation from the early universe. An appeal of the laboratory is that it uses real research equipment. The receivers are the same ones used in the BIMA/OVRO Sunyaev-Zel'dovich Effect experiment. We will also discuss possible ways to reproduce the laboratory equipment using less costly components while still retaining the spirit of the laboratory.

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