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A SEARCH FOR THE SUNYAEV-ZEL'DOVICH EFFECT AT MILLIMETER WAVELENGTHS

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ABSTRACT

We report an initial result in a program to measure the Sunyaev-Zel'dovich effect at frequencies from 3 to 10 cm^{-1}. The unique spectral characteristics of the effect and the small flux from contaminating astrophysical sources make the millimeter spectral region very attractive for this measurement. We show that the effect of atmospheric fluctuations can be greatly reduced by making multi-frequency measurements. Our measurement of the Zel'dovich effect in Abell 1795 results in a limit on the Comptonization parameter $\Delta y = (-0.4 \pm 1.7) \times 10^{-4}$ which corresponds to a $\Delta T_{RJ} = 0.2 \pm 0.9$ mK when referred to a change of brightness temperature in the Rayleigh-Jeans limit. These results are not corrected for the geometrical form factor which depends strongly on models of the cluster plasma.

Subject headings: cosmic background radiation — plasmas — radio sources: general

I. INTRODUCTION

X-ray emission from clusters of galaxies is believed to be due to the thermal bremsstrahlung from a hot plasma. The plasma column density and temperature derived from this model imply a measurable distortion of the cosmic background radiation (CBR) in the cluster direction (Sunyaev and Zel'dovich 1972). This distortion results from the Compton scattering of the CBR photons by the electrons in the plasma, resulting in an average increase in the energy of each photon (Wright 1979). This process, known as the Sunyaev-Zel'dovich effect, is photon conserving and, roughly speaking, "shifts" the CBR spectrum to higher frequencies. The measureable result is a decrease of flux at frequencies below 7.5 cm^{-1} (the Rayleigh-Jeans region), and an increase above. Figure 1 shows the spectrum of the effect at millimeter wavelengths.

Several efforts to measure this effect with coherent radio receiver techniques at frequencies between 0.25 and 1.1 cm^{-1} have been made (Lake and Partridge 1977; Birkinshaw, Gull, and Northover 1978; Rudnick 1978; Perrenod and Lada 1979; Lake and Partridge 1980; Boynton *et al.* 1982). We have begun a program of measuring the Sunyaev-Zel'dovich effect at frequencies between 3 and 10 cm^{-1} using bolometric techniques. We have made measurements in four simultaneous channels and have found that atmospheric fluctuations dominate the detector noise but can be greatly reduced by cross-correlating the spectral channels. In this *Letter* we describe our observing and analysis technique and report an initial null result for the cluster Abell 1795.

II. INSTRUMENTATION AND OBSERVATION

The observations were carried out with a four channel ^{3}He-cooled bolometer system on the Infrared Telescope Facility (IRTF) on Mauna Kea. The spectral response of the instrument channels is tailored to the measurement of the Zel'dovich effect in the presence of atmospheric noise. The channels operate simultaneously and are formed by a system of dichroic filters. The detector for each channel is a monolithic silicon bolometer of MIT design (Downey 1980) operated at 0.3 K with an electrical noise-equivalent power (NEP) of better than 4×10^{-16} Watts $Hz^{-1/2}$. The sensitivity of the entire system referenced to the top of the atmosphere is typically 20 Jy $Hz^{-1/2}$ or 15 mK $Hz^{-1/2}$ (Rayleigh-Jeans) in each channel.

During the observations, the telescope secondary chopper was used at a frequency of 5 Hz with a 5′ throw in declination. This throw is not sufficient for observations of nearby clusters with large angular core radii, but a larger throw resulted in an unacceptably large offset signal. The telescope was beam switched in declination every 50 s. The resulting beam pattern is a central spot on the cluster center and two reference spots 5′ to the north and south.

Poor weather and observing difficulties limited us to 1 hour of clean data on one cluster. The observations were made on 1982 April 16–18. The central beam position for Abell 1795 was R.A. = $13^h46^m30^s$ and decl. = $26^d50^m12^s$ (1950).

Mars was used to calibrate the system. The same chopping pattern was used for the calibration as the

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