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SUB-mm COSMOLOGY EXPERIMENTS WITH A CONTINUUM ARRAY RECEIVER

S. A. TORCHINSKY

Department of Astronomy Royal Observatory, Edinburgh, UK

The instrument

The Royal Observatory, Edinburgh is presently building an array receiver for the James Clerk Maxwell Telescope on Mauna Kea which will detect the submm continuum at 345 GHz (850 μm) and 660 GHz (450μm), and probably at two other channels: 430 GHz (700μm) and 860 GHz (350 μm). At the higher frequency there will be 81 bolometer-pixels in a hexagonal array with a 2 arcmin field of view. The lower frequency channel will have 37 pixels in the same field of view. The sensitivity of this Submm Common User Bolometer Array (SCUBA) will be roughly 50m Jy/$\sqrt{\text{Hz}}$ which is about ten times the sensitivity of the present single pixel continuum receiver at JMTC.

SCUBA will provide the best opportunities for ground based Cosmology, as it is so well suited to viewing the Cosmic Blackbody Radiation (peak at $\simeq$ 300 GHz). Experiments which look for Primeval Galaxies, Anisotropy, Sunyaev—Zel'dovich Effect, and Gravitational Lensing are possible and will be readily repeatable.

Primeval Galaxies and Dust Anisotropy

Primeval galaxies, which are generally thought to have a highly luminous phase due to an initial burst of star formation, have so far escaped detection in the optical and IR wavebands. This may be due to the PG being dusty and thus emitting its light in the Far IR. As an example of a possible detection of a PG, consider ARP220, a highly luminous, possibly star bursting galaxy. At a redshift of $z = 0.018$ its absolute luminosity has a peak of 120 Jy at 3000 GHz. Redshifted to $z \simeq 3$ the peak is $\sim$ 3.5 mJy at 860 GHz (with $\Omega_o h_o = 1$). SCUBA will be able to make a 5σ detection of the PG in $\sim$ 30 minutes. Due to the unique aeriel coverage provided by SCUBA, this experiment will enable fundamental constraints to be placed on theories of galaxy formation.

The expected emission by primeval dust (dust associated with star formation in primeval galaxies) has been calculated on the basis of the 'standard' Cold Dark Matter (CDM) model by Bond et al. [1, 2]. Significant spectral distortions were predicted in the submillimetre part of the microwave background. Looking for RMS fluctuations in the CBR of $\sim$ 1 % on scales of $\sim$ 10 arcsec is possible with the single element bolometer presently in use at JCMT. In fact, the experiment has been performed by Anthony Lazenby of Cambridge University (results pending). As a bolometer array, and with its greater sensitivity, SCUBA will be able to map a fully sampled region of about 2 arcminutes in about one tenth the integration time as one pixel element in Lazenby's experiment.

Sunyaev—Zel'dovich Effect

Occurring on larger angular scales, but somewhat more difficult to detect is the S—Z Effect. Compton Scattering of CBR photons through hot gas of galaxy clusters results in an increase of the intensity in the Wien end, and a decrease in the Rayleigh—Jeans end of the cosmic black body. Unfortunately, the low signal ($\Delta T/T \simeq 10^{-4}$) requires several hours integration time for a reasonable detection. The reward of a positive detection, however, is the possible direct measurement of H_0 when these observations are coupled with X-ray observations [3]. In addittion, mapping will provide direct information on the gas in the cluster, and thus also its mass profile.

Gravitational Lensing

A lens in transverse motion between an observer and a uniform radiation source causes a distinct signature in the uniform background which is roughly proportional to the speed of the lens [4, 5]. If a galaxy cluster is used as the gravitational lens, and the CBR the uniform background, then a deviation in the CBR of $\Delta T/T \simeq 10^{-4}$ might be expected. A few hours integration with SCUBA would give a measurement of the cluster's transverse velocity.

Some cosmological theories require the existence of Cosmic Strings for galaxy formation. These objects would be very thin, very massive and under high tension; the vibrational velocity of a string might be close to the speed of light. Looking in the direction of a cosmic string would result in a dramatic, unmistakeable line, like discontinuity as it acts as a linear gravitational lens [6].

R e f e r e n c e s:

1. Bond J. R., Carr B. J., Hogan C. J., Ap. J., 1986, vol. 306, pp. 428—450.
2. Unruh W. G., Semenoff G. W. (eds.), The Early Universe, 1988, D. Reidel Pub. Co., pp 283—334.
3. Silk J., White S. D. M., The Determination of qo Using X-Ray and Microwave Observations of Galaxy Clusters Ap. J., 1978, vol. 226, pp. L103—L106.
4. Birkinshaw M., Gull S. F., A Test for Transverse Motions of Clusters of Galaxies, Nature, 1983, vol. 302, pp. 315—317.
5. Sunyaev R. A., Zel'dovich Ya. B. The Velocity of Clusters of Galaxies Relative to the Microwave Background. The Possibility of its Measurement Mon. Not. R. Astr. Soc., 1980, vol. 18, pp. 537—560.
6. Kaiser N., Stebbins A., Microwave Anisotropy due to Cosmic Strings, Nature 1984, vol. 310, pp. 391—393.