Rich

PRELIMINARY DRAFT

PROPOSED MEASUREMENT OF THE COSMIC BLACK-BODY RADIATION NEAR THE COMA CLUSTER

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Dave x Cudaback

Adrian Webster

Any comments?

Rich

See comments,

L.

Measurement of the Cosmic Black-Body Radiation near the Coma Cluster

A. EXPERIMENT DESCRIPTION AND BACKGROUND

(1) General description and relevant theories.

The primary objective of the experiment is to check the isotropy of the 2.7 ^oK cosmic black-body radiation in the vicinity of the Coma cluster of galaxies. Sunyaev and Zeldovich (1969) predicted that a hot gas in the Coma cluster would scatter the relatively cool black-body photons into a higher frequency region, resulting in a decrease in the intensity of the radiation at the lower frequencies. They predicted a decrease of the order of 3 x10^{-3} ^oK, assuming an interstellar gas at T = 3 x10^8 ^oK and an electron density of $n_e = 10^{-3}$ cm^{-3}. Recently, in a paper that has appeared only in Russian, Parijskij (1972) claimed to see such a decrease: his measurements indicated that the radiation in the vicinity of the Coma cluster (at a wavelength of 4 cm.) was cooler than in the surrounding region by approximately 10^{-3} ^oK. In a more recent observation (Parijskij, 1973) he reported no such effect, at a level of approximately 10^{-4} ^oK. Recent theories ~~that~~ have attempted to account for the strong x-ray source observed in the cluster by the UHURU satellite by invoking the existence of ~~such~~ a hot gas in the cluster. (See, for example, Giacconi et al, 1971, and Morgon, 1973). ~~With~~

Parijskij's two experiments leave many questions unanswered, partially because his ~~articles~~ papers are very brief (he doesn't discuss possible sources of error) and partially because he doesn't discuss the contradictory results that he has reported. In this experiment we plan to do an experiment comparible in sensitivity to Parijskij's more sensitive experiment (1973), but to scan a somewhat different region of the Coma cluster, and to operate at a shorter wavelength (2 cm vs. 2.8 cm). We choose a scan away from a nearby radio source (5C4.85) that may have been a source of systematic error for Parijskij. In addition, the shorter wavelength should make us less sensitive to such background. ?? English system's beam.

Our basic procedure is to allow the Coma cluster to sweep past the 64 meter/advanced antenna ~~Goldstone antenna~~ sys. ~~operating at~~ The antenna is moved, and the sweep repeated. The data ~~is~~ are recorded, and subsequently signal-averaged in order to detect a deviation from the average in the direction of the ~~Coma~~ cluster.

As a secondary objective, we plan to measure the intensity of the radio source 5C4.81 (not to be confused with 5C4.85, mentioned on the previous page) at the wavelength of 2 cm. This source has several peculiar features which make a measurement of its spectrum interesting. M. Willson (1970) observed that its spectrum obeyed a considerably steeper power law (n=1.2) than that of ~~most~~ many radio sources. ~~(n=1.2)~~ The source is associated with the elliptical galaxy NGC 4869; however the source is not centered on this galaxy, but rather has a long tail extending several minutes of arc from it. It is possible that this galaxy is being affected by the nearby supergiant galaxy NGC 4874. We hope to get an accurate measurement of the radio intensity of 5C4.81 at 2 cm.

(2) Theoretical models: these have been discussed in section (1).

(3) Qualifications of the experimenters: vita are attached.

astronomers write m & s as superscripts. $12^h 56^m 30^s$

(4),(5) Experimental method and analysis.

We plan to use the 64-meter Advanced Antenna System, with the MXK feed cone at 2 cm., with the 50 MHz IF amplifier (bandwidth = 8 MHz). After an initial bore sight on 5C4.81, ~~The~~ the antenna will be set at the declination of 5C4.81, which is 28°10'50", and at a R.A. of 12h56m30s. The antenna will be held in a constant position for 1.5 min. while the motion of the earth causes the telescope to scan 1.5min. of R.A. (Drift Scan technique.) During this sweep, the ~~t~~ telescope will scan approximately ~~30 18~~ 20 seconds of "blank sky", followed by approximately 6 seconds to cross 5C4.81, followed by perhaps another 10 s. of blank sky as the region of the Coma cluster X-ray source approaches. ~~This scan is summarized~~ At this declination, according to the best available estimate (Lea et. al., 1973) the Coma x-ray source is approximately 20 s. across. The sweep would end with a final 34 seconds of "blank sky". ~~Th~~ The salient features of the sweep are summarized on the map on page 4.

This technique of scan was chosen to avoid angle-dependent noise and slewing noise. At the end of a 1.5 minute sweep, the antenna would be re-set to the R.A. of 12h56m30s, and a new ~~x~~ sweep begun. Each sweep affords approximately 6 seconds of observation of 5C4.81 and approximately 20 seconds of observation of the region of the Coma cluster which emits x-rays; the remaining 64 seconds of sweep will serve primarily as a calibration, although we will certainly look for structure in case it exists.

Our primary objective is to measure the black-body temperature of the Coma x-ray source, as compared to the nearby blank sky. In order to achieve a sensitivity of 2×10^{-4} °K (1 standard deviation level; ~~equal to~~ half as sensitive as Parijskij's ~~sensitivity~~ experiment),

~~we require an observation time of~~

$$\cancel{t = \left(\frac{T}{\Delta T}\right)^2 \frac{1}{B}}$$

keep in ' and separate

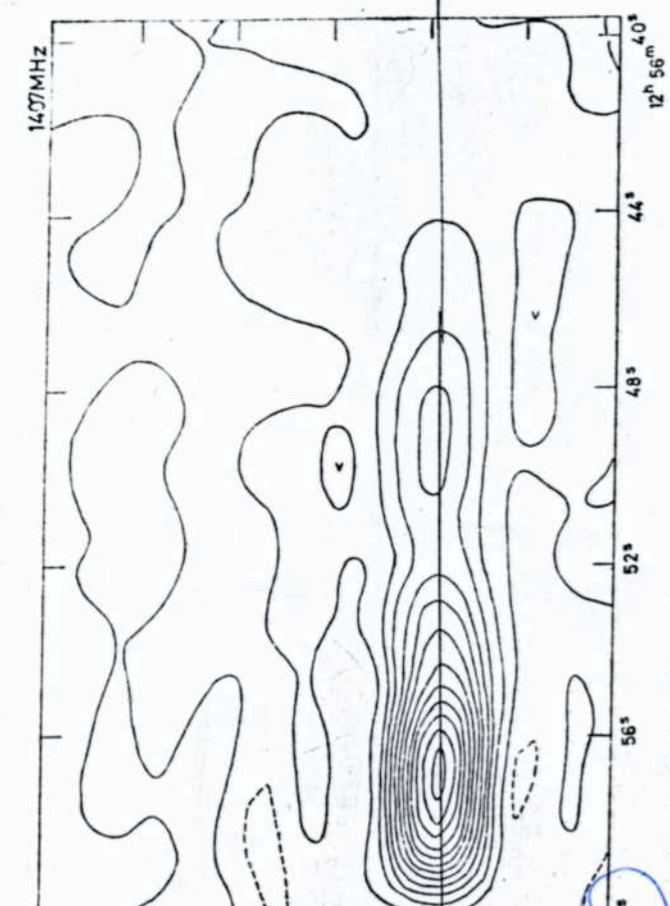

FIG. 5. Map of 5C4.81 (Sp source) and 5C4.85 (Nf source) at 1407 MHz.

note superscripts

Pointy accuracy: ? ± 1.2' or 1.2'

1.3' beam

planned sweep

deduced center of Coma cluster

extent of X-ray source

estimates quot
tions give the
higher resolut
5C4.81, 5C4.8
observations h
Observatic
(Friedman &

5.2. *Structure*

The maps
Figs 5 and 6.

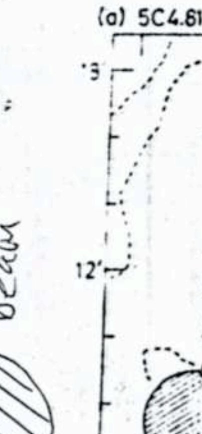

FIG. 6. (a) M
smoothed to

we require an integration time given by

$$t = \left(\frac{T}{e\ dT}\right)^2 \frac{1}{B}$$

where T is the antenna noise temperature, dT is the required sensitivity, e is the antenna efficiency, and B is the bandwidth. Setting $T = 29^{o}K$, $e = 0.4$, $dT = 2\ x10^{-4}\ {}^{o}K$, and $B = 8\ x10^{6}$, we find t = 16,500 seconds. If each 1.5 minute sweep passes over the Coma x-ray region for 20 seconds, we require a total of 825 sweeps, taking a total of about 20 hours.

For our secondary objective, we will measure the ~~flux~~ intensity of 5C4.81. To estimate the time required to do this, we can extrapolate the measurements of Willson (1970) using the spectral index of $n = 1.22$ deduced from his flux measurements of $1660\ x10^{-29}/w/m^2Hz$ at 408 MHz and of $367\ x10^{-29}\ w/m^2Hz$ at 1407 MHz.

Supposed 2 give pos $n = 1.2$ (negative sign is implied)

From this extrapolation, we estimate the intensity at 15 G Hz to be $2\ x10^{-28}\ w/m^2Hz$. For the 64 meter dish, this translates to an antenna temperature of $T_a = e\ S\ A\ /k$ where A is the antenna area and k is Boltzmann's constant. Substituting $A = 3217\ m^2$, $k = 1.38\ x10^{-23}$, $S = 2\ x10^{-28}$, and $e = 0.4$ yields $T_a = 18\ x10^{-3}\ {}^{o}K$. In the 6 seconds of integration time we take to cross the source, our sensitivity (1 s.d.) would be $4\ x10^{-3}\ {}^{o}K$. Thus we should see the source on each sweep, if the extrapolation is correct. If the source is considerably weaker, the bore sight would require the use of a signal averager,

~~with less than 1 second integration, and thus it should appea~~
~~experiment (it should be visible/in the first sweep), and then concentrate on the Coma Cluster measurements, improving our sensitivity in this region.~~

you haven't mentioned this so far — Does this mean Deep Space Net?

6. Characteristics of the DSN facility unique for this experiment.

The 64-Meter Advanced Antenna System has several features which are essential for this experiment. The large aperature size, and low noise temperature are essential, as was shown in the previous section. The resolution of the antenna (1.3') is closely matched to our requirements, since the source 5C4.81 is ~~approximately~~ just under 1' in angular size. In addition it will be necessary to use the pointing accuracy of the telescope ~~(0.02° = 1.2')~~ ($\pm 0.01° = \pm 0.6'$ peak to peak) to its full advantage.

X.

B. EXPERIMENT IMPLEMENTATION

We will supply computer tape, and (if one is not available) a signal averager for real-time observations of 5C4.81. No modifications of existing DSN equipment, ~~xxxxxx~~ and no special staffing are anticipated. We will be able to make our observations on any ~~date~~ two consecutive days following August 4, 1973. (R. Muller has a committment until Aug. 4 that makes it impossible to do the experiment before then.) In August, the Coma Cluster will be ~~xxxxxxxxxxxxxxxxxxxxxxxxx~~ about 4 hours to the left of the sun; the best observations times would be ~~x 1~~ 2 pm to ~~5~~ 6 pm PST.

If you want it symmetric about the meridian

~~X~~LIST OF EXPERIMENTERS, names, ~~xxxxxxxx~~ addresses, and phone numbers.

EXPERIMENT DATA ANALYSIS AND REPORTING

The data will be analyzed ~~xx~~ at the CDC 7600 computer facility at the Lawrence Berkeley Laboratory, Berkeley California. The analysis consists primarily of a signal average of each of the consectutive 1.5 minute runs~~x.xxxx~~ The results will be published in the Astrophysical Journal.

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