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# STUDIES IN COSMIC RADIO NOISE AT BANGALORE

## Spectral Index of Background Radiation

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ABSTRACT

From the results of the 28.6 Mc/s background survey of the cosmic radiation at Bangalore, a value of 2.37 is obtained for the spectral index. The significance of this value is briefly discussed. Regions where the index is different are ascribed to brighter belts of emission and absorbing ionized hydrogen clouds.

### INTRODUCTION

In an earlier paper[1] the equipment for studies in cosmic noise at Bangalore on a frequency of 28.6 Mc/s was described. A survey of the background radiation has been in progress for over a year now and the sky temperatures have been determined over the declination range $0^\circ$ to $+26^\circ$. Detailed contour maps of this survey will be published in due course. In this paper it is proposed to discuss the value of the spectral index obtained for the background radiation.

It has been established by many authors that generally the sky temperature increases with decreasing frequency. This variation of temperature with frequency can be written as,

$$T \propto f^{-\alpha} \tag{1}$$

Here $\alpha$ is the spectral index of the radio radiation. Several values lying in the range 2 to 3 have been ascribed to the spectral index. Radioastronomy

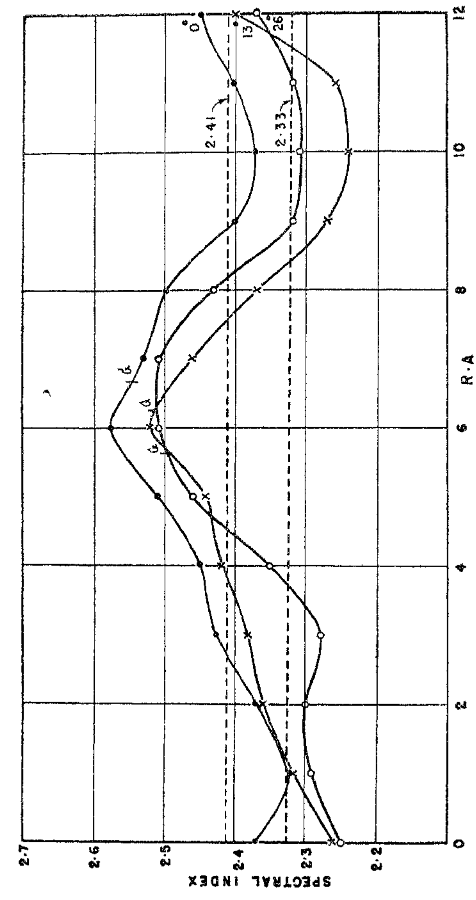


FIG. I

measurements at high frequencies have poor accuracy where absolute values of temperature are concerned though for a given survey, the relative values at different regions are known more accurately. Beams of widely differing areas are used and methods of restoring the true sky temperatures from the observed aerial temperatures are highly complex and are only approximate.[2] In view of the above two limitations, a rather large variation in the computed values of $\alpha$ is to be expected.

The spectral index is determined by comparing the temperatures obtained at a given point in the sky at two different frequencies. From equation (1) we can write,

$$\alpha = \frac{\log T_2 - \log T_1}{\log f_1 - \log f_2} \tag{2}$$

where $T_1$ and $T_2$ are temperatures at frequencies $f_1$ and $f_2$ respectively. If two surveys far apart in freqency are chosen for comparison, variations in $\alpha$ due to inaccuracies in the measurement of $T$ will be reduced to a minimum, but genuine variations in $\alpha$ will also be masked. This is a result of the fact that the process of taking logarithms tends to smooth out variations. Keeping this in view, the survey of Kraus and Ko[3] at 250 Mc/s has been chosen for comparison with our survey at 28.6 Mc/s. This has the additional advantage of being a comparatively narrow beam survey at metre wavelengths, covering the portion of the sky covered by the present work.

## Experimental Technique

Measurements made with the 28.6 Mc/s broadside array[1] have been used to obtain maps of the sky. Only the observations taken during the period $00^h$ to $06^h$ IST were used, since it was found that during this period the ionospheric effects were least important. A beam of $10^\circ.5$ by $16^\circ.5$ half power beamwidth was used and the observed curves were corrected using the chord construction method of Bracewell[4]. The correction was made only in the east-west direction. From the corrected curves thus obtained the effects of the localized sources were removed by neglecting the localized enhancements over the general background, as was done by Shain.[5] From the resulting temperature distribution, the spectral index was calculated.

## Results and Discussion

1. *Spectral Index*:—The spectral index was calculated at hourly intervals on the three declinations, $0^\circ, +13^\circ$ and $+26^\circ$. The values are plotted in figs. I and II. The spectral index is found to vary over the entire sky. From the curves obtained, a spectral index of $2.37 \pm 0.04$, which is the value given by Costain[6] working at 38.0 Mc/s and 117 Mc/s with identical beams, appears to be satisfactory.

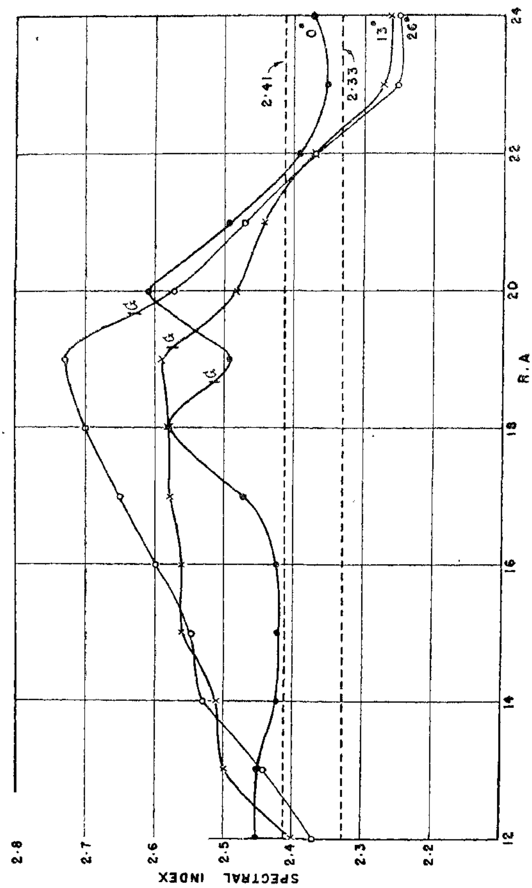
SPECTRAL INDEX
2·8
2·7
2·6
2·5
2·4
2·3
2·2
R.A
12
14
16
18
20
22
24
2·41
2·33
0°
13°
26°

FIG. II

The radiation coming from the sky can be divided into three main categories :

(1) Non-thermal emission from the galaxy ;

(2) Non-thermal emission from extragalactic regions ;

(3) Thermal emission from extragalactic regions.

If the effect of the localized sources had not been removed, we would have had to consider radiation from them also. The spectral index for each of the above components is different since their origin itself is different in each case. The spectral index of 2.37 mentioned above pertains to non-thermal emission from extra galactic regions and non thermal emission from the galaxy with similar underlying physical processes. In places where the temperature corresponds to a higher index it is to be concluded that there is a belt of emission which is brighter than that given by an index of 2.37. On the other hand, in places where the index appears to be lower, it is to be expected that certain absorbing regions are present between the source and the sun which cause a reduction in the temperature. These two regions are discussed below.

From the data available, it is not possible to ascribe an accurate value to the spectral index in view of an inherent limitation. The values for temperature given by Kraus and Ko are actually the temperatures in excess of the temperature of the coldest part of the sky. This temperature cannot be accurately estimated and the value given by them is $80^{\circ} \pm 30^{\circ}$K. The temperature at the regions away from the galactic equator, on the basis of which the spectral index of 2.37 has been obtained are of the order of $90^{\circ}$K, so that there could be an error of as much as 30% in the temperature. This is of course the extreme limit and there is no reason to expect such a large error in their determination. However, in view of this possibly serious limitation, no accurate value of the spectral index is proposed to be given here. But Costain's value of $2.37 \pm 0.04$ is adopted since it has been obtained at 38 Mc/s which is fairly close to the operating frequency. In figs. I and II, the region corresponding to $2.37 \pm 0.04$ is marked by the dashed lines. Deviations from this spectral index are ascribed to the special features mentioned earlier. In view of the limitations to an accurate determination of the spectral index, minor variations of the spectral index are neglected. These can be studied in more detail when results of the proposed survey with an identical beam at 62 Mc/s become available.

Westerhout[7] from an analysis or the results of different workers giving due weightage to the accuracies, arrived at a value of 2.7 for the spectral index which is somewhat higher than the value obtained by the authors. Only near the galactic equator have such high values been obtained by the authors. Moxon[8] working at low frequencies, (40, 90 and 200 Mc/s) has obtained a spectral index of 2.1 in the cold parts of the sky and 2 69 at the regions of maximum intensity. This is more nearly the situation observed by the authors, the lowest value obtained being 2.23 and the highest value 2.73. From a consideration of the results of Costain, Moxon, Kraus and Ko and the authors, the value of about 2.37 appears to be a reasonable one at the low frequencies for the non-thermal component of radio emission. A more detailed analysis of the spectral index at metre wavelengths taking into account the origin of the radiation is being undertaken, using the results of the 62 Mc/s survey also and will be published later.

2. *Absorption Regions*:—The most probable cause for the lower index obtained in some regions is the presence of ionized hydrogen clouds which tend to absorb the radiation. These clouds absorb low frequency radiation to a greater extent than high frequency radiation and this tends to reflect itself as a low spectral index.

From figs. I and II, it can be seen that there is an extended belt of absorption from about $22^h 30^m$ to $01^h 00^m$ R.A. on the declinations of $+13^\circ$ and $+26^\circ$. This is absent on the $0^\circ$ declination. On $+26^\circ$, the belt possibly extends further till about $03^h 30^m$. It can be concluded that there exists a cloud of ionized hydrogen which is more extensive towards the north and vanishing towards the south. The exact extent and nature of the clouds can be determined only with the use of narrower beams and more precise instruments.

3. *Bright belt*:—Radiation in excess of that to be expected from a spectral index of 2.37 has been observed at 28.6 Mc/s near the galactic equator. From the Figures I and II, this region of enhanced emission is seen to extend some distance on either side of the galactic equator, which is marked on each declination curve (G). The belt seems to extend northwards, the northern declination curve giving the highest value and the southern declination curve the lowest value, near the galactic center (around $18^h 30^m$ R.A.). At the anti-center region, the enhancement appears to be of about the same magnitude on all the declination curves. This belt extends from about $04^h 00^m$ to $08^h 00^m$ and again from $13^h 00^m$ to $20^h 00^m$. In the latter region, another feature can be noticed. The belt of emission extends a little further towards the galactic north pole (corresponding to the lesser R.A.s) than on the other side. This region is probably a combination of the $15^\circ$ (galactic latitude) broad belt of emission and the peninsula extending northwards noticed by Ko[9].

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