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ref : rkm4/SUN1/aug91

Aug. 24, 1991

SOLAR OBSERVATIONS WITH A SINGLE GMRT-DISH

For a strong radio source like the Sun, the antenna temperature due to the source is much much greater than the receiver temperature. The system noise temperature, therefore, is dominated by the source temperature and it is found that beyond a certain point, increasing the collecting area of the dish does not help as the increase in the signal due to a larger collecting area is neutralized by a proportionate increase in the rms of the fluctuations in the antenna temperature and the SNR remains constant.

ANALYSIS :

Let

$\Delta\nu$ = *System Bandwidth*

τ = *Integration Time*

T_{sys} = *System Temperature*

Then,

$$\Delta T_{rms} = \frac{T_{sys}}{\sqrt{\tau \Delta\nu}}$$

Now

$$T_{sys} = T_A + T_R$$

where

T_A = Antenna Temperature due to the Source only

and

T_R = Receiver Noise Temperature

Since the SNR is given by :

$$\text{SNR} = \frac{T_A}{\Delta T_{rms}}$$

$$= \frac{\sqrt{\tau \Delta \nu}}{1+\frac{T_R}{T_A}}$$

Therefore, when $T_A >> T_R$,

$$\text{SNR} = \sqrt{\tau \Delta \nu} = \text{Independent of the Signal Strength } T_A$$

However

$$T_A = \frac{\eta S A}{2k}$$

Where

η = Aperture Efficiency

A = Physical Collecting Area of the Dish

$$= \frac{\pi D^2}{4}$$

S = Flux Density of the Source

k = Boltzman Constant

For a given S, the Antenna Temperature due to the source – T_A increases linearly with the increase in the collecting area. Therefore, beyond a certain limit, $T_A >> T_R$ and from (i) we see that any further increase in the collecting area would not improve the SNR.

CALCULATIONS for the GMRT DISH :

The following values have been assumed for the calculations :

$T_R = 120 \quad K \quad$ (at 327 MHz)

$S_{QuietSun} = 10^{-21} \quad W \quad m^{-2} \quad Hz^{-1}$

$\eta = 0.6$

It turns out that for a Dish of Diameter 2.5 m , contribution to the system temperature T_{sys} from T_A will be equal to that from T_R when one is observing the Sun.

For the contribution of the T_R to be 10 % of that of T_A, the Diameter required is about 8.5 m.

And T_R becomes just 1 % of T_A for a Dish of Diameter 25 m.

With the GMRT Dish of Diameter 45 m, we have $T_A = 480 T_R$.

CONCLUSIONS :

Since even for a 25 m Dish $T_A >> T_R$, large Diameter of 45 m has no extra advantage over a 25 m Dish for Solar Observations.

REFERENCES :

1. Anantharamaiah et al, Lecture 23 in "Synthesis Imaging in Radio Astronomy", vol. 6, 1998.

2. Nelson et al, Chapter 6 in "Solar Radiophysics", edited by McClean and Labrum.