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Radio Astronomy Terms Explained

Those with an interest in radio-astronomy are always asking what the main parameters of an operational radio astronomy installation are. The most important parameters and formulae are listed below.

1.

The antenna

a) Diameter of parabola: D (m)

b) Depth of parabola: c (m)

c) The focal length (focus):

$$f = \frac{D^2}{16c}(m)$$

d) Antenna area:

$$A_{geo} = \frac{D^2\pi}{4}(m^2)$$

e) Antenna area efficiency η: (normally lies between 0.45 and 0.65). 0.55 can be taken as a good average. Determined by measuring a known radio source.

f) Effective antenna area:

$$A_{eff} = A_{geo} \cdot \eta(m^2)$$

g) The aperture angle, as in optics, depends on the dimensions (diameter) of the antenna and the wavelength. It gives the angle at which half the power is measured between the points, and is approximately:

Angle in degrees $= 70 \cdot \frac{\lambda}{D}$

2.

Receiver

Noise factor of receiver: in decibels (F) or kT0

$$F_{(db)} = 10 \cdot \log kT_0$$

or noise temperature of receiver: TE

$$F_{(db)} = 10 \cdot \log \frac{290 + T_E}{290}$$

The value of F(db), kT0 or TE is determined through measurement.

3.

Flux of a radio source

$$FluxS\left(\frac{W}{m^2 Hz}\right)$$

Since the flux from radio sources is very low, the value inserted is

$$10^{-26}\frac{W}{m^2 Hz} = 1Jansky$$

The flux parameter SFU (Solar Flux Unit) is used for solar measurements:

$$1SFU = 10^{-22}\frac{W}{m^2 Hz}$$

4.

System noise temperature

In measurements, the noise of the receiver (F, kT0, TE) is supplemented by a noise fraction which is caused by the ohmic losses of the antenna, the secondary lobes of the antenna, the radiation from the atmosphere (in front of the antenna), unresolved radio sources at greater distances and the 3k background radiation.

$$T_{system} = T_E + T_H$$

TH is the sum of the previously calculated radiation temperature contributions and can be set as approximately 35 K in the range of 1-10 GHz. If a radio source is measured, the system temperature is supplemented by the radiation temperature of the radio source. The signal sterngth is measured in decibels (db) or in Kelvins (T), if the installation has been calibrated in temperatures, for example:

$$Signalstrength(db) = 10\cdot\log\frac{T_{sys}+T_{Aquelle}}{T_{sys}}$$

5.

Important relationships

$$S = 2\frac{k\cdot T_{Aquelle}}{A_{eff}}$$

$$k = 1.38\cdot 10^{-23}\frac{J}{k}$$

(Boltzmann constants)

Factor 2 results from the fact that an unpolarised radiator is being measured with a polarised antenna.

Conversion of effective antenna area into isotropic antenna gain.

$$A_{eff} = \frac{\lambda^2}{4\pi}G_{iso}$$

$$G_{iso} = \frac{4\pi}{\lambda^2}A_{eff}$$

$$G_{iso} = G_{Dipol} + 2.3db$$

Relationship between isotropic antenna gain and system noise temperature:

$$\frac{G_{iso}}{T_{sys}} = 0.385\cdot 10^6\frac{\left(10^{db/10}-1\right)\cdot f^2(GHz)}{S_{jy}}$$

Temperature of a radio source:

$$S = 7.35\cdot T\cdot D^2\cdot f^2\left[\frac{W}{m^2 Hz}\cdot 10^{-26}\right]$$

$$T = \frac{S}{7.35\cdot D^2\cdot f^2}[K]$$

derived from Rayleigh/Jeans with:

$$S\left[\frac{W}{m^2 Hz}\cdot 10^{-26}\right], T[K], D$$

6.

Literature references

[1] VHF Communications, 2/95 Pp. 112-122, H. Hagn, Reception parameter measurements with radio stars

[2] The ARRL UHF/Microwave Experimenters Manual, 7-60; David B. Schaffer, Microwave System Calibration using the Sun and Moon