

# How to determine antenna temperature in solar radio astronomy?

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**Abstract.** Several equations like the SETI equation (SETI, 1997) exist how to determine the antenna temperature  $T_a$  by knowing the flux  $S$  of the source, the gain  $G$  of the antenna and the receiving frequency  $f$  respective wavelength  $\lambda$ . Here a couple of tailored or fitted parametric equations are shown and developed to easily calculate the antenna temperature  $T_a$  at the terminals of the receiving feed.

**Key words.** Flux, solar flux, frequency, wavelength, Effective area, Boltzmann Constant.

## 1. Theory

Originally the antenna temperature  $T_a$  for one polarization according to (Kraus, 1965) is given by

$$T_a = \frac{S A_e}{2 k} \quad (1)$$

where  $S$  is the flux of a radio source and  $A_e$  the effective area of the receiving antenna. The constant  $k$  is the so called *Boltzmann Constant*  $k = 1.380662 * 10^{-23} J/K$ . Here the effective area  $A_e$  of the antenna can be replaced by another equivalent definition, namely

$$A_e = \frac{G \lambda^2}{4\pi} \quad (2)$$

where  $G$  stands for antenna gain given in units and  $\lambda$  for wavelength given in meter. If we put Eqs. 1 and 2 together we then get

$$T_a = \frac{S}{2 k} \frac{G \lambda^2}{4\pi} \quad (3)$$

All physical and mathematical constants can be pre calculated which then leads to

$$T_a = \frac{S G \lambda^2}{3.4700 \cdot 10^{-22}} \quad (4)$$

As one can easily recognize this is a quite nice formula because if we remember the units of the solar radio flux ( $1\text{sfu} = 10^{-22} W s/m^2$ ) we can simplify Eq. 4 to

$$T_a = \frac{S G \lambda^2}{3.47}, \quad S[\text{sfu}], \lambda[m] \quad (5)$$

Of course instead of using wavelength  $\lambda$  we can also implement an equation that uses frequency  $f$  instead

$$T_a = \frac{S G}{38.555 f^2}, \quad S[\text{sfu}], f[\text{GHz}] \quad (6)$$

## 2. Final result

Eq. 5 and Eq. 6 are rather simple and can be learned by hard very easily. They are very practical for daily usage. Nevertheless I personally suggest Eq. 1 for long time remembering. For special purposes it may be useful to work with a modified version of Eq. 1 by pre calculating the constant values

$$T_a = S A_e 3.6215, \quad S[\text{sfu}], A_e[m^2] \quad (7)$$

If you work with one of the above equations taking flux in Jansky instead of sfu, please don't forget to put in the transformation factor

$$1\text{sfu} = 10^4 FU = 10^{-22} W s/m^2 \quad (8)$$

where

$$1\text{Jansky} = 1FU = 10^{-26} W/m^2/Hz \quad (9)$$

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## References

- Ian Drummond VE6IXD, SETI Publications Department, <http://www.setileague.org/articles/sunnoise.htm>, (originally taken from the ARRL Manual, page 7-58).
- John D. Kraus, Radio Astronomy 2nd edition, Cygnus-Quasar Books, 1986, p. 3-40, Eq. 3-113.