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 Ta by knowing the flux S of the source, the gain G of the antenna and the receiving frequency f respective wavelength λ. Here a couple of tailored or fitted parametric equations are shown and developed to easily calculate the antenna temperature Ta at the terminals of the receiving feed.

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

1. Theory

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

$$T_a = \frac{S A_e}{2\ k} \tag{1}$$

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

$$A_e = \frac{G\ \lambda^2}{4\pi} \tag{2}$$

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

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

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

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

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

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

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

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

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

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

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

$$1sfu = 10^4 FU = 10^{-22} Ws/m^2 \tag{8}$$

where

$$1Jansky = 1FU = 10^{-26} W/m^2/Hz \tag{9}$$

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References

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