DATA ANALYSIS - COSMIC MICROWAVE RADIOMETER

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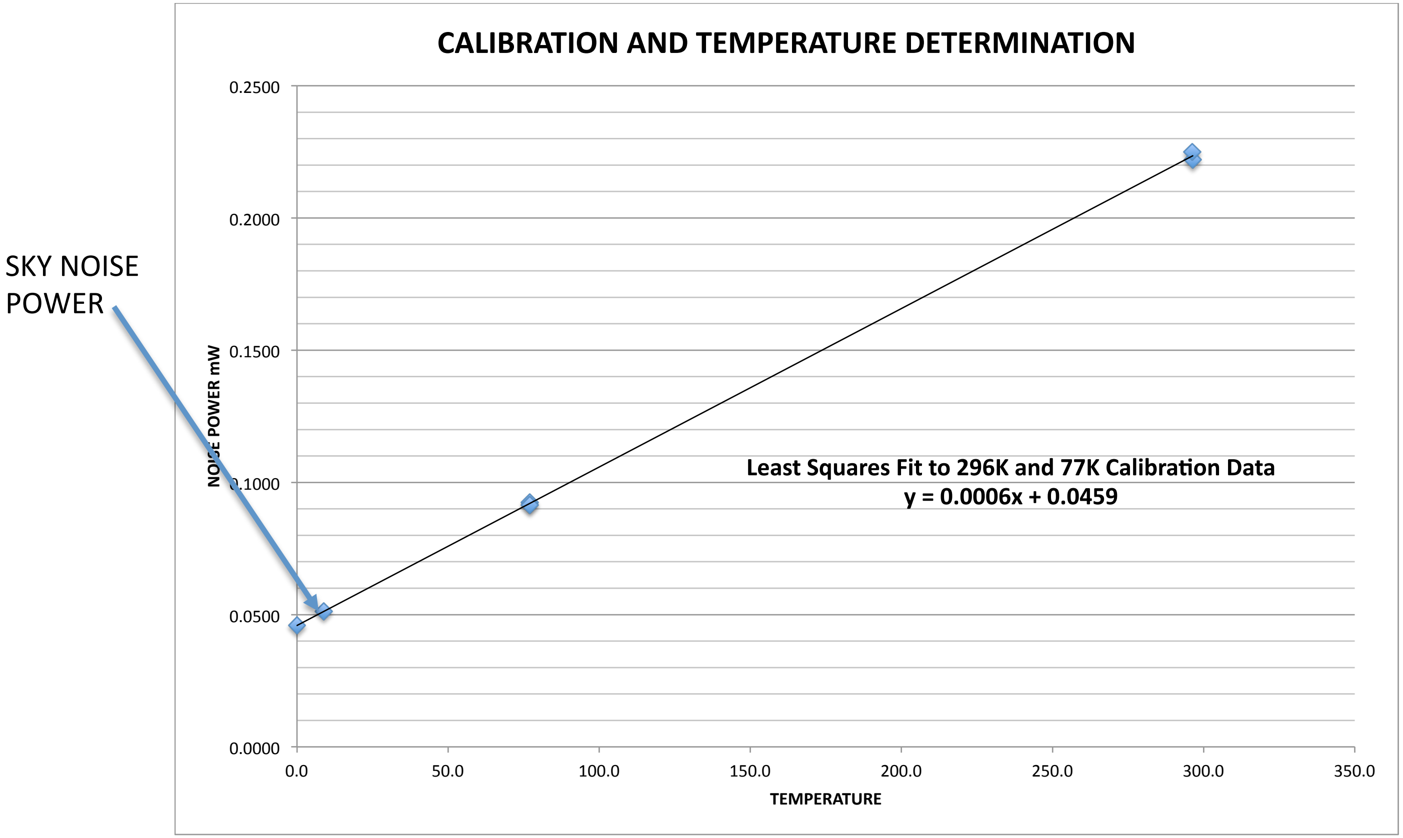
BLACK BODY TEMPERATURE MEASUREMENT

- The measurement configuration in our experiment is that of a total power radiometer.
- We are operating in the region of the Raleigh-Jeans approximation to the low frequency end of the Black Body curve.
- In the Raleigh-Jeans region the total noise power signal, P, intercepted at the antenna is directly proportional to temperature of the antenna,

  P = k T(ant) B

- Where k is the Boltzman constant, T(ant) is the temperature observed at the antenna, and B is the frequency bandwidth.
- In this regime, temperature measured by microwave noise power at the antenna corresponds to the actual (thermodynamic) temperature of the radiating sources.
- Contributions to the total noise temperature are additive. For example under the conditions in the observation described here,
- T (antenna) = T (CMB) + T (atmosphere) + T (amplifier noise)
- This simplifies the analysis of the measurements because the total measured noise power is also additive.
- This fact allows us to calibrate the response of the radiometer with two calibration temperatures and use a linear extrapolation to determine T (Sky).

DATA REDUCTION



The noise power data at 296K (room temperature) and 77K (Liquid nitrogen temperature) is least squares fitted to a line, The value of measured sky noise power is plotted on the calibration line. The measured value of the temperature of the sky is read off of the x-axis.

This graphical representation is borrowed from the Y-Method, which uses a two temperature calibration to measure the noise performance of an amplifier. See Agilent reference.

RESULTS

Temperature calibration

$$G = \frac{T(ant, amb) - T(ant, cold)}{S(amb) - S(cold)}$$

Least squares fit to data produces a calibration line of the form y=mx + b.
S = GT + S(0) = 0.0006 T + 0.0459

Average measured total power from sky, S(sky), is substituted into the calibration equation
Average = 0.0513 mW
(S(sky) – S(0))/G = T(sky)
T(sky) = 8.9K

For a clear sky at sea level, the correction for atmospheric emissivity is approximately 5.2 K (Stein and Forster, 2008)

CMB temperature = 8.9 – 5.2 = 3.7 K

Accepted CMB temperature value= 2.73K

The notation here is taken from the Bersanelli references.

Where,

G = gain calibration, also can be called the slope of the calibration line.

S = measured signal at the output of the radiometer

S(amb) = signal when pointed at ambient temperature source

S(Cold) = signal when pointed at cold load

S(0) = system signal at the point where the calibration line crosses the Y axis. It is the intrinsic noise of the system when there is no external signal.

T = antenna temperature under the conditions noted