Radio Astronomy and Interferometry 2015
Demonstrations, Set 2

8. The gain drift of a receiver system $\Delta G/G$ is 1%. The receiver temperature T_R = 100 K, bandwidth B = 1 GHz, and integration time τ = 1 s.
The antenna is looking at the Sun (T_A = 7000 K) and the Dicke radiometer reference is at room temperature (300 K). What is the minimum detectable noise temperature ΔT_{min}?

9. What is the ΔT_{min} if the radiometer in question 8 is properly balanced?

10. What is the minimum point source flux density, in SFU, on the surface of the Sun (T = 7000 K) that can be detected with the Metsähovi 13.7 m radio telescope? Assume DPFU = 0.027, with the fully balanced Dicke radiometer in questions 8-9.

11. Calculate an estimate of T_A for the Metsähovi (D = 13.7 m) antenna for a 0.5 Jy source at 43 GHz. Illumination efficiency is 50% and surface RMS errors are σ = 50 μm. What is the DPFU at this frequency?

12. Suppose we know that the Earth atmosphere has a temperature of T = 300 K and an optical depth of τ = 0.1.
a) What is the excess noise from the atmosphere when observing celestial sources with a radio telescope? (Think again how the radiation transfer equation works.)
b) If τ is related to the optical depth in the zenith by $\tau = \frac{\tau_z}{sin(elevation)}$, determine τ at elevations 15, 30, 50, and 70 degrees (elevation is the angle relative to the horizon). What is the effect on the source temperature at each antenna elevation?

13.The Heinrich Hertz submillimeter telescope at Mt. Graham has a diameter of 10 m and a beam efficiency of 0.4 at 350 μm wavelength. At 350 μm the atmospheric transmission is 5%.
a) Show that the transmission is equivalent to τ = 3.
b) What is the sky noise for this situation if the physical temperature of the sky is 200 K?

14.a) If the average electron density in the interstellar medium (ISM) is 0.03 cm^{-3}, what is the lowest frequency of electromagnetic radiation which one can receive due to the plasma cutoff?
14.b) Compare this to the ionospheric cutoff frequency if the electron density in the ionosphere is $\sim 3\times10^5$ cm^{-3}.