

# Exercise 4: Atmospheric Brightness Temperature Spectra

Sample Solution

Effective: 26.01.2017

1. Use the ARTS control file `rtcalc.arts` and Matlab plotting script `plot_bt.m` to calculate and display the spectrum of atmospheric zenith opacity in the microwave spectral range for a midlatitude-summer atmosphere. There are four spectral lines in the plot.

## Questions

- To which species do these lines belong? (You can find this out by playing with the absorption species selection in the ARTS control file.)
- We speak of window regions where the zenith opacity is below 1. Where are they?

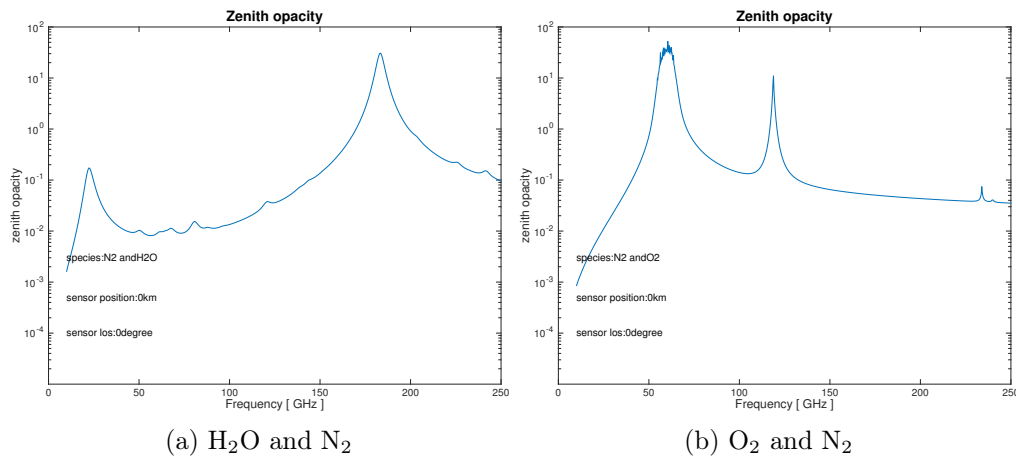


Figure 1: Zenith opacity separately for O<sub>2</sub> and H<sub>2</sub>O molecules.

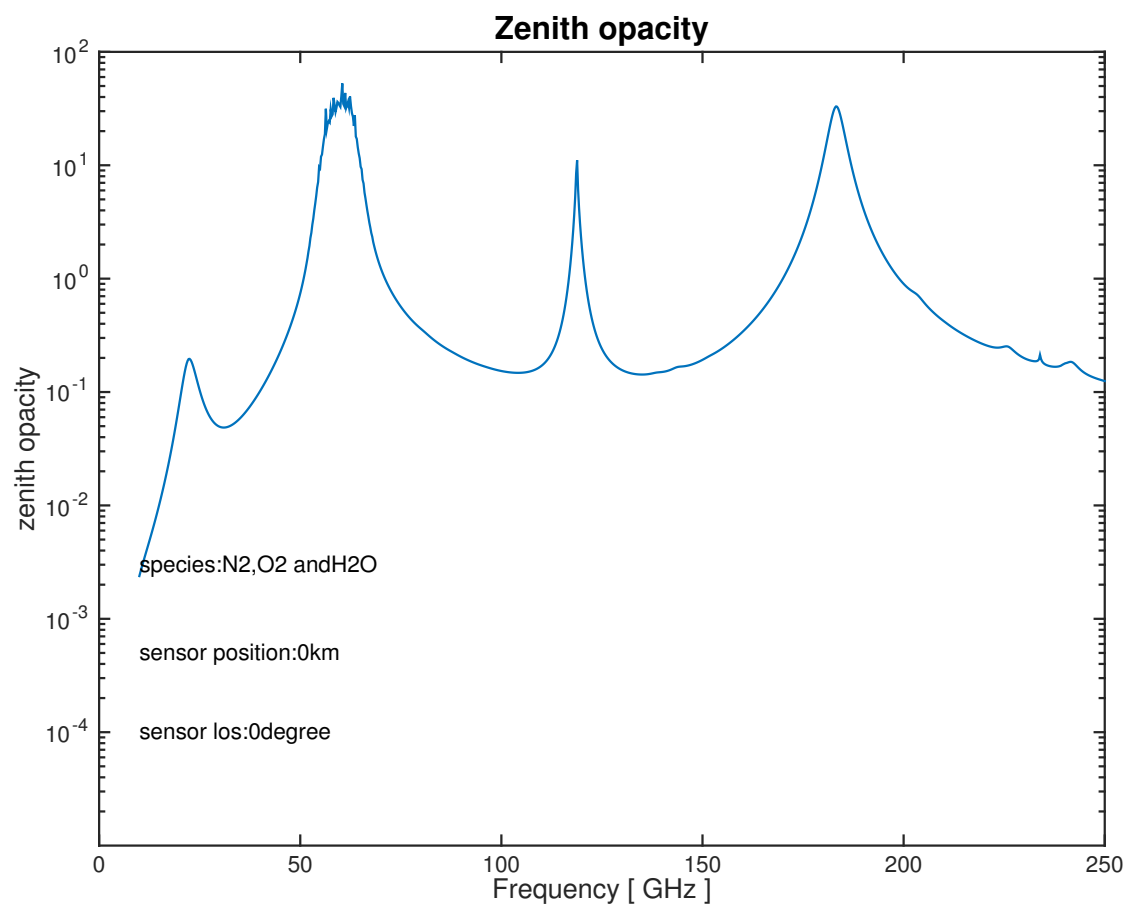
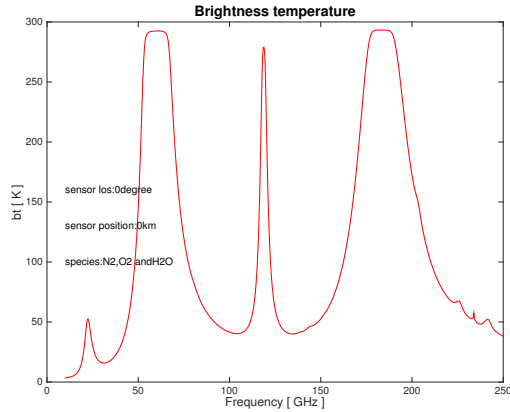


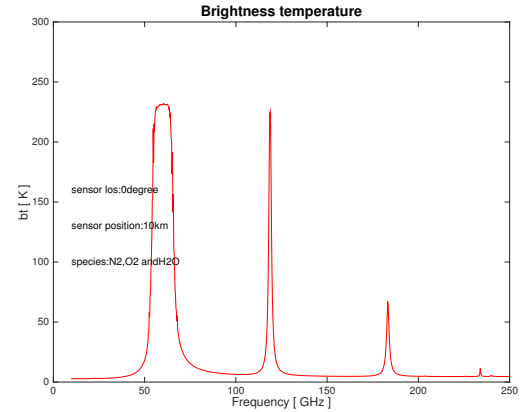
Figure 2: Zenith opacity.

2. Brightness temperature is a unit for intensity. It is the temperature that a blackbody should have to give the same intensity as measured. Mathematically, the transformation between intensity in SI units and intensity in brightness temperature is done with the Planck formula. Calculate and display the atmospheric brightness temperature spectrum for different hypothetical sensors:

- A ground-based sensor looking in the zenith direction.
- A sensor on an airplane ( $z = 10$  km) looking in the zenith direction.



(a) Ground based.



(b) 10 km height.

Figure 3: Brightness temperature for a sensor positioned at the ground and at 10 km height.

### Questions

- In Plot (a), why do the lines near 60 GHz and near 180 GHz appear flat on top?
- In Plot (b), why is the line at 180 GHz smaller than the line at 120 GHz, although its zenith opacity is higher?
- Describe the difference between plots (a) and (b). What happens to the lines, what happens to the background? Can you explain what you see?

3. Make the same calculation for a satellite sensor ( $z = 800$  km) looking nadir (straight down).

#### Questions

- Why is the line at 180 GHz “upside-down”, but the one at 20 GHz not?
- Explain the funny shape of the  $O_2$  line at 120 GHz.

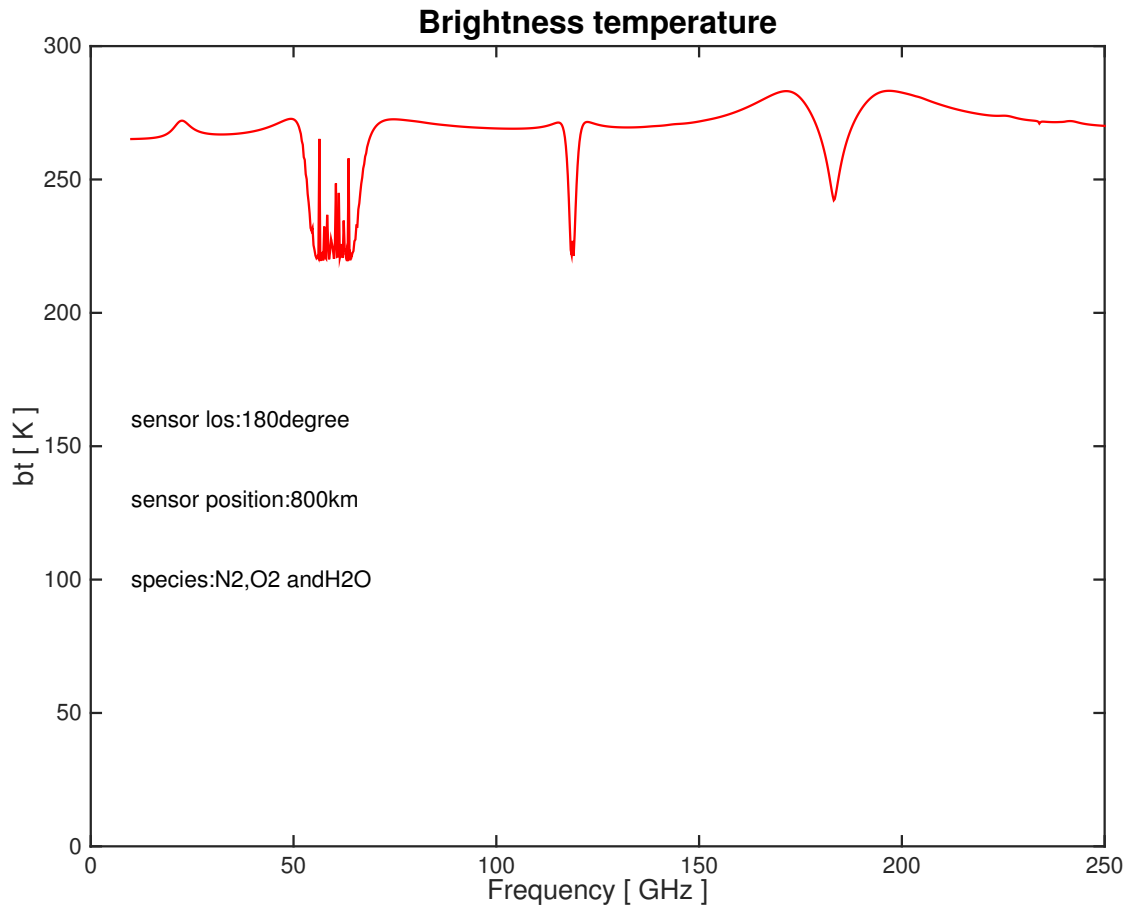


Figure 4: Brightness temperature seen from a sensor looking down.