

**Labs in Brienza
Menzel
Lab 0 – Planck Function**

1. Open the Planck Tool and familiarize yourself with the display (see Figure 1 below) which opens with energy/time/area/solid angle/wavelength for a 6000 K target (e.g. the Sun).

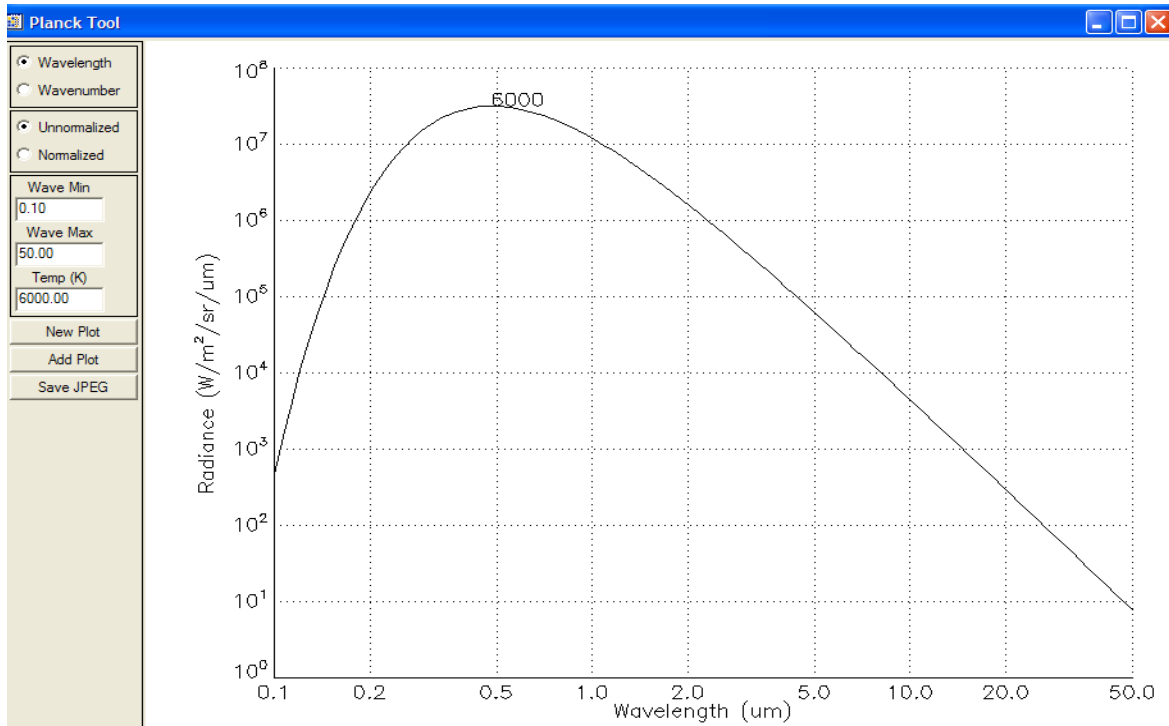


Figure 1: Planck Tool default display; note that the temperature label is placed near the peak of the Planck curve.

1a. Add plots for 4000, 1000, 500, 300, and 200 K.

1b. Verify Wiens Law that $\lambda_{\max} \text{ (cm)} = .3 / T \text{ (deg K)}$

1c. Verify that $B(\lambda_{\max}, T) \propto T^5$. What does this imply about incoming solar versus outgoing terrestrial radiances as represented by $B(0.5 \mu\text{m}, 6000 \text{ K}) / B(10 \mu\text{m}, 300 \text{ K})$?

1d. Inspect the 6000 K and 300 K curves and qualitatively establish that $\int B(\lambda, T) d\lambda \propto T^4$ as Stefans Law requires. Note the log scale for radiance.

1e. Inspect the 6000 K curve and verify that $\int_0^{\lambda_{\max}} B(\lambda, T) d\lambda \sim 1/3 \int_0^{\infty} B(\lambda, T) d\lambda$.

1f. Start a new plot for $B(\lambda, 6000 \text{ K})$ and add $B(\lambda, 300 \text{ K})$. Display these two plots in normalized radiance units. Where are the relative percentages of solar and earth emitted radiation likely to be the same?

2. Using wavenumbers (instead of wavelengths) restart the Planck Tool. Use wave min = 0.1 cm^{-1} , wave max = 20000 cm^{-1} , and $T = 1000 \text{ K}$.

2a. Add plots for 500, 300, and 200 K.

2b. Verify Wiens Law that $\nu_{\text{max}} (\text{cm}^{-1}) = 2 * T (\text{deg K})$

2c. Verify that $B(\nu_{\text{max}}, T) \propto T^3$.

3. Start the Planck Calculator. Familiarize yourself with the commands.

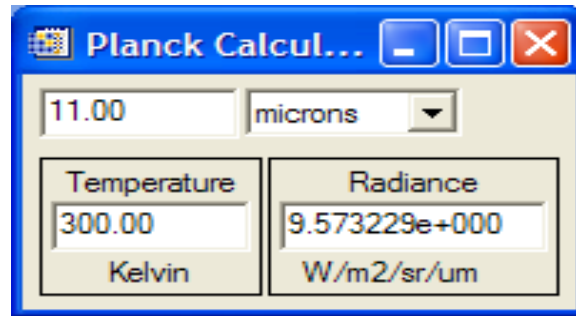


Figure 2: Planck Calculator display

3a. Make a plot of $B(10 \mu\text{m}, T) / B(10 \mu\text{m}, 270 \text{ K})$ for terrestrial temperatures (e.g. 200, 220, 240, 260, 280, 300, 320 K). Record the values from the Planck calculator and plot them on a graph.

3b. Make a plot of $B(4 \mu\text{m}, T) / B(4 \mu\text{m}, 270 \text{ K})$ for terrestrial temperatures (e.g. 200, 220, 240, 260, 280, 300, 320 K). Record the values from the Planck calculator and plot them on the same graph.

3c. Make a plot of $B(0.3 \text{ cm}, T) / B(0.3 \text{ cm}, 270 \text{ K})$ for terrestrial temperatures (e.g. 200, 220, 240, 260, 280, 300, 320 K). Record the values from the Planck calculator and plot them on the same graph.

3d. Temperature sensitivity, a , is defined by $\text{dB}/B = a * \text{dT}/T$. This is a measure of the percentage radiance change versus the percentage temperature change. Use the Planck calculator to determine the temperature sensitivity at 200 and 300 K for the shortwave ($4 \mu\text{m}$) and longwave ($10 \mu\text{m}$) infrared windows? Does this agree with your graph from 3a and 3b? Which window is most sensitive to changes in the earth surface temperature?

4. Consider a field of view (FOV) with a fraction N containing cloud at 200 K and $(1-N)$ containing earth surface at 300 K in clear sky. The brightness temperature for this FOV is given by

$$BT(10 \mu\text{m}, N) = B^{-1}[N*B(10 \mu\text{m}, 200 \text{ K})+(1-N)*B(10 \mu\text{m}, 300 \text{ K})].$$

4a. Using the Planck calculator make a plot of the brightness temperatures $BT(10 \mu\text{m}, N)$ for $N = 0.0, 0.2, 0.4, 0.6, 0.8,$ and 1.0 . Do the same for $BT(4 \mu\text{m}, N)$ on the same plot. Does this suggest a test for broken or scattered clouds?

4b. Using the Planck calculator determine the radiances at 8, 11, 12 μm for a scene of clear sky at 300 K and a cloud at 230 K with varying cloud amount. Let the cloud fraction vary from $N = 0.0, 0.2, 0.4, 0.6, 0.8,$ and 1.0 . Convert the radiances to brightness temperatures. Plot brightness temperature differences 8 - 11 versus 11 - 12 for the six different cloud fractions.