Questions to discuss during the lectures for part 1D

Important: You also need the lecture notes for part 1D to read together with this guide.
Also note: The lecture guides are made for use during the lectures. They will not make much sense if you are not present at the lecture, in this case, go directly to the lecture notes. You may then use the lecture guide after reading the lecture notes to test your understanding.

1. What is a blackbody?

2. Given that flux F is the energy ΔE that passes through an area ΔA per time interval Δt, and luminosity L is total energy emitted by an object ($\Delta E/\Delta t$), **discuss how you would go about to solve exercise 1D.3, starting from problem 3** (note that the project students will need a similar calculation in challenge B of part 3). **Important info:** You may use the Stefan-Boltzmann law $F = \sigma T^4$. Instead of using your generated solar system, use for now the Sun and a space probe orbiting Saturn. Assume for simplicity that the surface temperature of the Sun is 6000K, the distance from the Sun to Saturn is 10AU and the radius of the Sun is 7×10^5km. **NOTE: you are not supposed to calculate numbers here, just understand how you would do it.**

3. Discuss how to solve exercise 1D.4 (similar to a part of challenge B in part 3 of the project), you should still use the Sun and Saturn here. Remember that for equilibrium, the total energy received by and the total energy emitted from a planet needs to be equal. Use the approximation of a disc as described in the exercise. Assume for simplicity a radius of 60.000km for Saturn.

4. The flux per wavelength ($\Delta E/(\Delta A \Delta t \Delta\lambda)$) of a blackbody is given by

$$F(\lambda) = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{hv/(kT\lambda)} - 1}$$

   Discuss how you would use this to derive Stefan-Boltzmann's law.

5. Discuss how you would use this to find at which wavelenght λ a blackbody with temperature T radiates most of its energy? After you have a rough idea on how to do this, then look at exercise 1D2 (but replace $B(\lambda)$ by $F(\lambda)$ everywhere in the text).

6. Solve exercise 1D.3, problem 1 for the Sun (assume 6000K).

7. How would you generalize the definition of an angle to 2 dimensions?

8. Discuss how you would solve 1D.1

9. Discuss how you would derive the expression for $F(\lambda)$ from the expression for $B(\lambda)$ (this is similar to, but not exactly the same as exercise 1D.5)

10. What is a spectral line, and how does it arise?

11. In figure 1, leftmost plot, you see a spectral line from a given element taken from the light it emits when heated in the laboratory. The rightmost plot shows the same spectral line from the same element, but observed in the light from a star. Discuss:

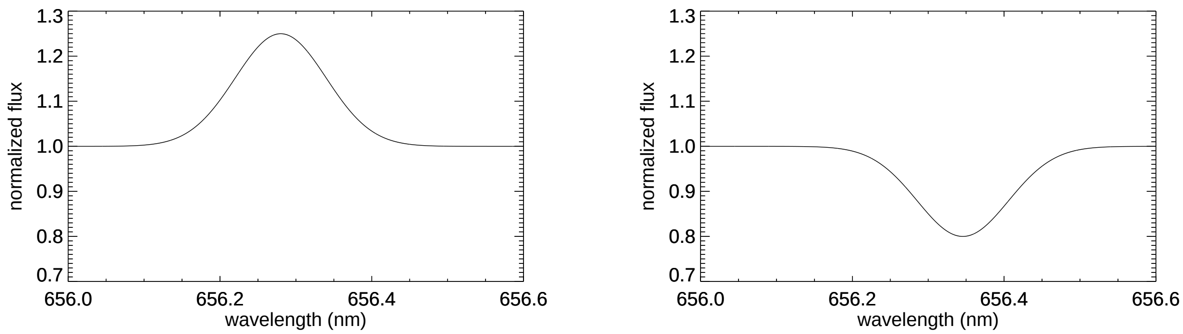

Figure 1: Left: the spectral line measured in the laboratory, right: the same line from the same element observed in light from a star.

(a) Why is the radiation stronger at the wavelength of the spectral line in the laboratory, while it is weaker in the light from the star?

(b) Why is the wavelenght of the center of the line at a slightly different wavelength in the light from the star?

(c) What could possibly determine the depth of the line in the light from the star?

(d) What could possibly determine the width of the line in the light from the star?

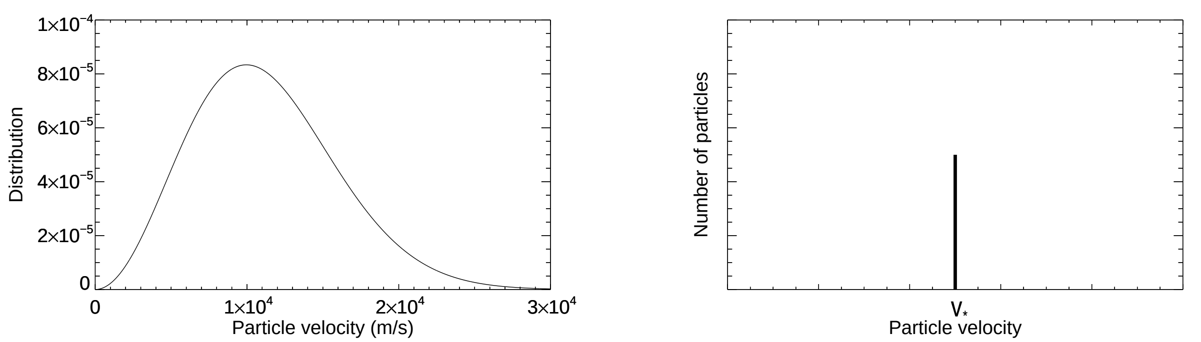

Figure 2: Left: The Maxwell-Boltzmann distribution for velocity v for hydrogen gas at the solar surface (6000K), right: the simplified delta-function distribution which we will use to approximate Maxwell-Boltzmann.

12. Assume now, instead of using a normal Maxwell-Boltzmann distribution for the velocity of gas

particles, we use the distribution shown in figure 2 where all particles have velocity v_*. Discuss how you think the shape of the spectral line would look like in this case.

13. Discuss how you could obtain the width of the spectral line expressed in terms of v_*.

14. Looking at the Maxwell-Boltzmann distribution in figure 2, discuss which velocity you would use as v_* in order to get a good approximation to the Maxwell-Boltzmann distribution.

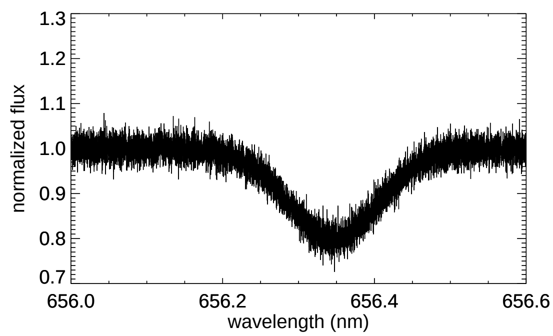

Figure 3: The noisy observation of a spectral line.

15. Assume that the spectral line has the Gaussian bell shape. Supposed you need to find the position and width from the noisy observation of a spectral line in figure 3 using least squares method. In order to do this, in analogy to the previous chapter on extrasolar planets, you need a model for the spectral line. Discuss how you can write an analytical expression for this model and which free parameters you need to fit for in the least squares method.

16. How would you go about to find reasonable intervals for σ (the standard deviation of the Gaussian shape) in a numerical implementation of the least squares methods?

17. Discuss how you could solve 1D.6

18. Discuss how you could solve 1D.7.