UCF Physics: AST 6165 Planetary Atmospheres

Spring 2020 Homework 1, DUE Thursday, 16 January 2020

Reading for this assignment: Andrews, Chapter 1

Problems:

This is an extension of a problem given in the book and in class. The math is simple, but most years prior to the use of the following list of hints, most students did very badly, about 50% or worse. Some things to consider:

- If thermal conductivity is good, then the whole planet has the same temperature. It emits uniformly, but the input of energy will still vary over the surface.
- If thermal conductivity is poor, then regions of the planet, perhaps rings or small patches, will have the same temperature, and the problem must be solved for each such region independently.
- Think *very carefully* about the geometry of the subregion of the planet that is in thermal equilibrium (i.e., at the same temperature) and the cross-section of the radiation heating it.
- The input regions have to account for the angle between the surface and the direction of sunlight, though sometimes this can be done with a geometric trick, as in the book's example. The output regions never do.
- The input region shape can be thought of as a (nearly) flat 2D figure, a section taken out of the expanding sphere of sunlight. To get an idea of this, visualize the input region as though you were on the sun looking at the planet, and also sideways and from above the beam. Under what limited circumstances will 2D regions involve π? The output region is a portion of a sphere.
- In the past, I have given these problems in several different orders. The results are remarkable: whatever students do for the earlier problems seems to bias how the later ones are done. These are three *very different* problems. Think each one through from scratch, and use these hints! Check your answers by applying physical intuition. What should the curves look like? What should the maximum temperatures be?

For this assignment, use the stellar surface temperature, T_*, and relevant distances, not the solar constant.

1. (10 points) For a spherical, airless world that efficiently conducts heat and that is in a circular orbit of radius a, derive an expression for the surface temperature. Calculate it (see above).
2. (20 points) If this body is thermally insulating, has zero obliquity, and spins rapidly, derive an expression for the temperature *vs.* latitude. Plot it.

3. (20 points) If this body is thermally insulating and is tidally locked (always faces the same side to the star), derive an expression for the surface temperature *vs.* central meridian latitude. Plot it.

4. (0 points) Give your preferences for talks to the instructor.