Student name: AST221H
Student #: **Assignment 4** Due: Nov. 27, 2020

You may work together with other students to solve these problem sets, but all solutions must be written and submitted independently. Submit your assignment as a single .pdf file following the instructions on Quercus. ***Part marks only will be given for solutions with no explanation. Show your work, including intermediate steps and diagrams if necessary!*** *Check the syllabus for reading recommendations. Careful with units!*

Problem 1: Asteroid rotation

For many asteroids, we can't tell whether they are a single, solid 'rock' or a self-gravitating 'rubble pile'. Here, you will examine an asteroid's light curve to see if you can derive any constraints. Asteroids exhibit time-varying brightness due to their asymmetric shapes. As they spin, they present a different size reflecting surface between the sun and our telescopes (think of spinning a potato on its axis, and imagining how much light reflects back to you from its surface!).

1. The asteroid 2867 Steins' lightcurve is attached (Figure 1). Estimate its rotation period.

2. Steins orbits in a relatively circular orbit at about 2 au from the Sun. A typical asteroid has an albedo, or reflectivity, of about $A \sim 0.3$. At our closest approach to Steins we make a measurement of the flux coming from the asteroid to be about 2×10^{-12} erg s^{-1} cm^{-2}. What is its radius?

3. Can Steins be a rubble pile, or must it be a solid body? Assume the asteroid's density is roughly the same as the Earth's. Hint: consider gravitational vs. centrifugal acceleration of a test mass on its surface.

4. Given the size you derived in 2), what is the critical rotation rate?

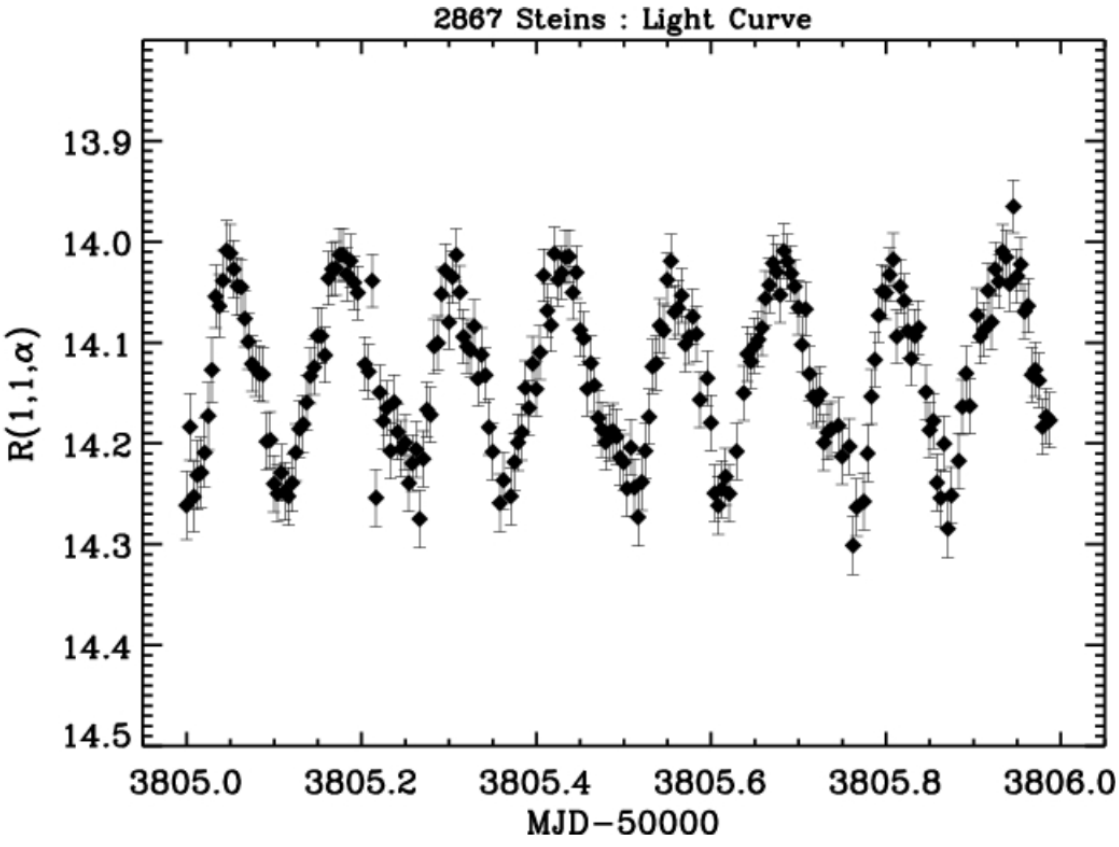

Figure 1: Steins 2867 light curve

Problem 2: Neptune's atmosphere

Neptune orbits the Sun at a distance $r = 30.1$ au. It has mass $M_N = 1.02 \times 10^{29}$ g, radius $R_N = 2.48 \times 10^9$ cm, and albedo $A \sim 0.31$.

1. Compute Neptune's equilibrium temperature, based on the Sun's radius and surface temperature (you can take these from C&O).

2. Find the temperature required for hydrogen molecules (H_2) to escape Neptune's gravitational field. (Be sure to show your reasoning and work.)

3. Compare your results for (a) and (b). Is it surprising that Neptune has retained its hydrogen?

4. Would Neptune still be able to retain its hydrogen if it orbited the Sun at a distance of 0.1 au? Why or why not?