ASTR/GEOL-2040-001: Search for Life in the Universe

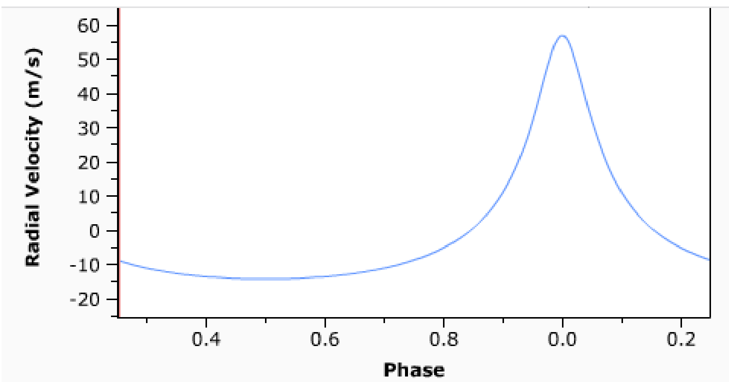
Homework #6   Due: Friday December 8, 2017

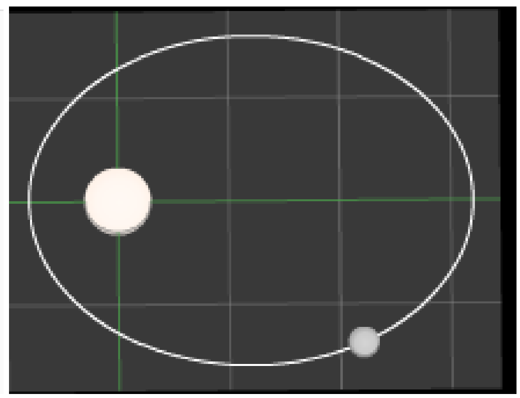
1. An extraterrestrial is sending you the following message.

   1 1 0 1 1 0 1 0 1 0 0 1 1 1 0 0 0 1 0 0 1 0 1 0 1 0 1 1 1 0 0 0 1 0 0

   Look at Figure 9.9 of the Rothery et al. book and assume that this extraterrestrial is sending you a picture just like in this figure. Draw this picture and write what you see. [6pts]

2. Below you see a curve of the radial velocity versus time (or phase). The curve is rather asymmetric. In the other figure below you see an elliptic orbit. Positive velocities corresponds to a *star* moving away from the observer.



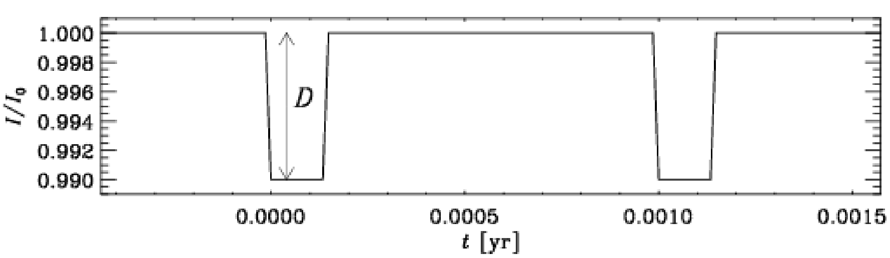


   (a) Reproduce the sketch with the elliptic orbit of planet and star orbiting around a common center of mass. Indicate the direction in which the bodies orbit with arrows. [2pts]

   (b) The observer measures a temporal change of the frequency of spectral lines. Explain how a velocity can be measured in this way and of which of the two bodies. [2pts]

   (c) In which direction does the observer lie? Indicate the position in your sketch. Sketch the time dependence of the radial velocity from other viewing angles to make sure your answer is correct. [2pts]

3. Below is a light curve of a solar "twin" with periodic dips. Intensity I is normalized by the maximum value, I_0. This solar twin has a radius just like the Sun ($R = 700,000\,\mathrm{km}$) and the same mass as our Sun. Thus, you can write Kepler's law as $P^2 = r^3$ if the orbital period P is measured in yr and the orbital radius r is measured in AU.



   (a) How long is the orbital period P of the planet (in yr)? [3pts]

   (b) What is the radius r of the planet's orbit (in AU)? [3pts]

4. Figure 1 shows a $400\,\mathrm{km} \times 400\,\mathrm{km} = (400\,\mathrm{km})^2$ patch with "synthetic" lunar craters. Determine the age of the surface hosting these craters using the left panel of Figure 2, where isochrones are shown in a graph showing the number count $N(D)$ versus diameter D per $10^6\,\mathrm{km}^2$ for constant logarithmic mass bins (corresponding roughly to the intervals between 32–48 km, 48–64 km, 64–96 km, etc).

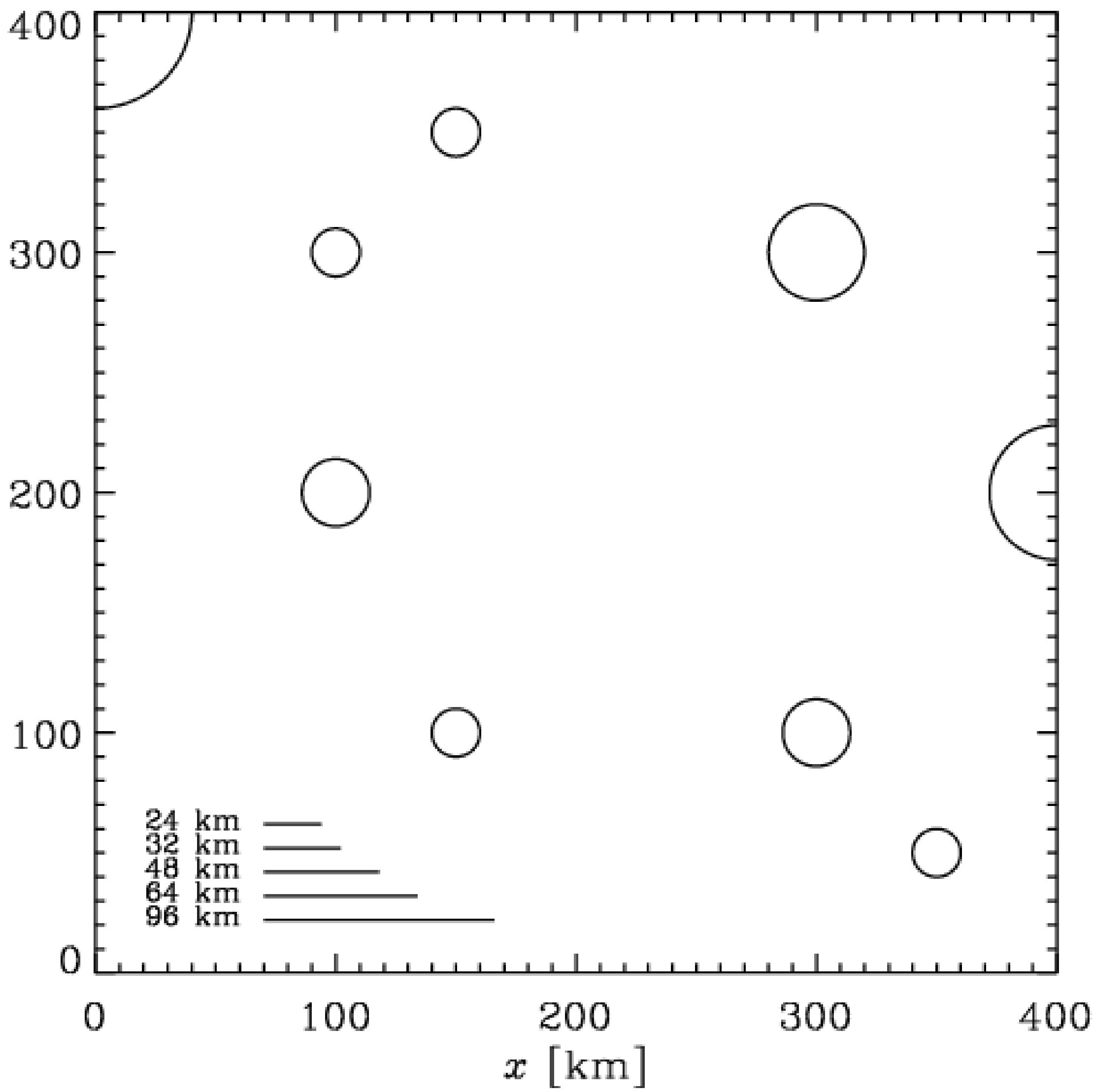


Figure 1: $400\,\mathrm{km} \times 400\,\mathrm{km} = (400\,\mathrm{km})^2$ patch with "synthetic" lunar craters.

(a) Count the number of craters for each of the 5 size bins given in the table below and enter that number in the 2nd column, which is the number count per $(400\,\mathrm{km})^2$. Count 1/2 craters as 1/2, etc. [2pts]

(b) To use the left panel of Figure 2, convert your number count to one per $10^6\,\mathrm{km}^2$ and enter those values in the 3rd column. [2pts]

(c) Check whether you did this right: should the value in column 3 be larger or smaller than the value in column 2? [2pts]

(d) Overplot these values in Fig. 1 and, thus, [2pts]

(e) estimate the age of the surface. [2pts]

(f) The isochrones in the figure obey $N(D) \propto D^{-q}$, where N is the number count and D the radius. What is the value of the exponent q? Indicate your working in the figure and on this paper (e.g., mark approximate decades on the axes.) [2pts]

size range	crater count per $(400\,\mathrm{km})^2$	crater count per $(1000\,\mathrm{km})^2$
16–24 km		
24–32 km		
32–48 km		
48–64 km		
64–96 km		

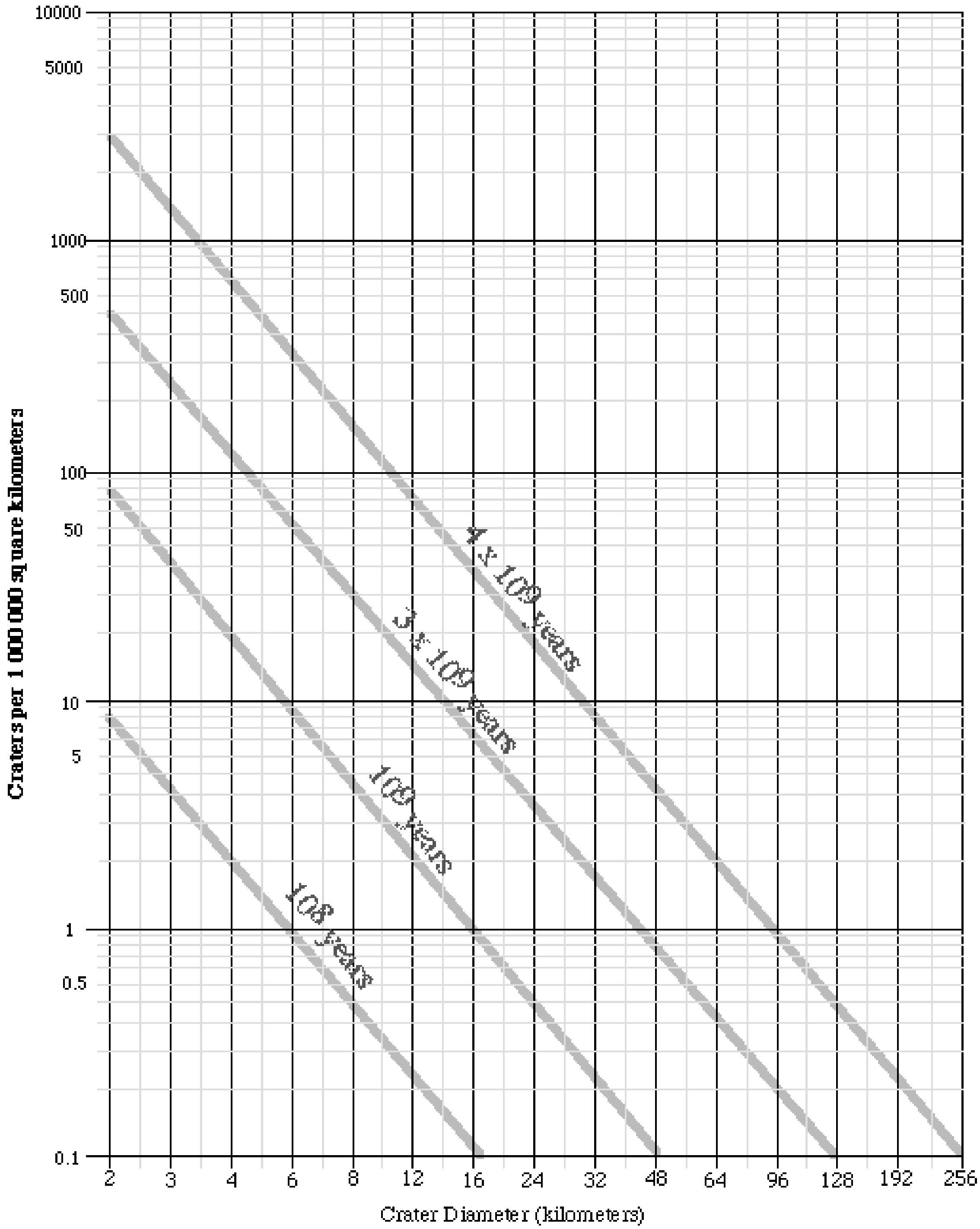


Figure 2: *Left:* isochrones of crater counts **per** $10^6\,\mathrm{km}^2$ per logarithmic size (diameter) interval (e.g., between 24 and 32, or between 32 and 48) in a plot of $N(D)$. *Right:* a region some 400 km southwest of Mare Nectaris, near the landing site of Apollo 16. As a *bonus exercise*, try your luck with such a real photo of lunar craters!