Astronomy 16 – Modern Astrophysics
Fall 2014
Week 1

Questions for the week:

1. How big is the Moon, given its apparent size and distance?
2. How bright is the full Moon relative to the Sun?

By the end of the week, you will be able to answer these questions.

Topics:

Angles, distance-size-angle relationship
Size and distance scale of the nearby universe
Parallax
Circular motion, centripetal acceleration
Newtonian gravity, orbits, Kepler's third law, the virial theorem, and mass determination

In this first week we will cover a relatively wide range of interrelated topics, all of which will help us answer some basic questions about the scale of the Earth, Moon, Sun, Solar System, and nearby stars, and about the properties of these objects, including their sizes and masses.

We'll start with describing positions, sizes, and motions of objects as they appear in the sky, and use your observations of the crescent Moon to make these concepts more concrete. We'll bring in more real physics: gravity, circular motion, and light as

the week goes on. And as the semester progresses, we will generally employ more and more physics to understand more and more properties of astronomical objects – mostly stars (like, what elements are stars composed of? what's their energy source? what happens to stars as they age?). This week, though, we'll start nearby and basic. I think you'll be surprised and interested in just how much we can figure out with very little special input information (e.g. without telescopic observations, just naked-eye observations).

Reading:

As with the reading for most weeks, I am going to associate much of the specified reading assignment with particular concepts we'll be covering in class – and which will appear on the homework. Some reading will generally be specified as "required" while other reading will be designated "optional" – that's material that you don't need to know in order to get a good understanding of the required material and the main topics we'll be covering in class, but which you might find interesting based on your required reading and the nature of the main topics. There's a third category, "skim" which indicates that you should be reading this material in order to prepare for class, but you don't have to read it with the highest level of focus on detail that the required reading demands. Generally I'll ask you to skim something when the figures and their captions have useful information but the text, including equations, gives you more detail than I feel you absolutely need in order to understand the main focus of the week's material.

So, for the first week of classes, you should read Ryden and Peterson, parts of Chs. 1, 2, 3, and 13, as follows:

Read sec. 1.1 (pp. 1-3) and then skim sec. 1.2 (pp. 3 – 9), paying close attention to the figures and to the meanings of "altitude" and "azimuth" as well as declination, hour angle, and right ascension.

Skim sec. 1.3, 1.4, and the first two pages of sec. 1.5 (solar vs. sidereal day is a distinction it would be good to understand).

The rest of sec. 1.5 is optional, but you should read sec. 1.6.

The historical development of astronomy described in Ch. 2 is interesting, and you should read the whole chapter. There are bits in there that are useful more generally and/or especially important (moon phases are discussed briefly at the top of p. 30; Eratosthenes's measurement of the size of the Earth – Fig. 2.2 – is key for human understanding of the scale of the universe; parallax (pp. 37-38 and 58-59) is very important). The details of finding the orbital periods and orbital radii of other planets (pp. 41-46) is less important and can be skimmed. But Galileo's telescopic observations and how they provided several types of evidence for the modern, heliocentric system, is very important, as are Kepler's three laws.

Skim Ch. 3, on orbital mechanics, but read the last, short section, 3.4 (pp. 78-80), on the virial theorem, carefully. We may not get to it in class until the beginning of week 2, though.

Finally, for the relationship between observed brightness and intrinsic luminosity, read the beginning of sec. 13.2 (p. 309) through the bottom of p. 310.

Important concepts and related facts to keep in mind as you read, and make sure you can answer while/after you've done the reading. We will discuss all of these in class this week.

As you read about angular measure (p. 3) think about how the radian is defined and see if you can find or compute the number of degrees in a radian.

Get comfortable thinking about the apparent distance between two stars you see in the sky as an *angle* – the angular separation. It literally is the angle between your two arms if you point one of them at one star and the other one at the other star. And for a single, large object we talk about its *angular size* or the angle it *subtends*.

What are the units of luminosity and of flux? If two identical light bulbs are different distances away from you, which one looks dimmer to you? How would you use the inverse square law (eq. 13.7) to compute their relative distances from you given your measurement of their relative brightnesses, or fluxes?

You should be familiar with Newtonian gravity (eq. 3.1 on p. 62) and also you should review the basics of uniform circular motion (not covered directly in the reading), especially the expression for centripetal acceleration for uniform circular motion with speed *v* and radius of motion *r*.

How do *you* think about an orbit? What keeps the orbiting object moving in a circle? (Always consider circular orbits of a light object orbiting a much heavier object, first – it's the easiest case to analyze.)

Make sure you understand Eratosthenes's measurement, his model of the Earth-Sun-two-observer system, and the sketch shown in Fig. 2.2. And also Galileo's observations of Venus and how they showed that the Ptolemaic Earth-centered system couldn't be right and how they were consistent with the Copernican Sun-centered system.