AST 301: Topics for today

1. **Syllabus.** You should have read the syllabus in detail. So only *brief* questions about course, grading, etc. today.

   Go to the course web site and bookmark it as soon as possible.

2. **The Textbook.** What to buy, how to use.

3. Important preliminaries:

Scientific notation, e.g. 3×10^{18} cm, 2×10^{-5}, …

Distances to planets, stars, galaxies, the extent of the observable universe.

Graphs—if you don't get used to them quickly, you can't understand the material.

Adjusting to strange units. Completely arbitrary, you just need to get used to them and know what to associate them with.

Examples: Distances, angles, sizes in astronomy.

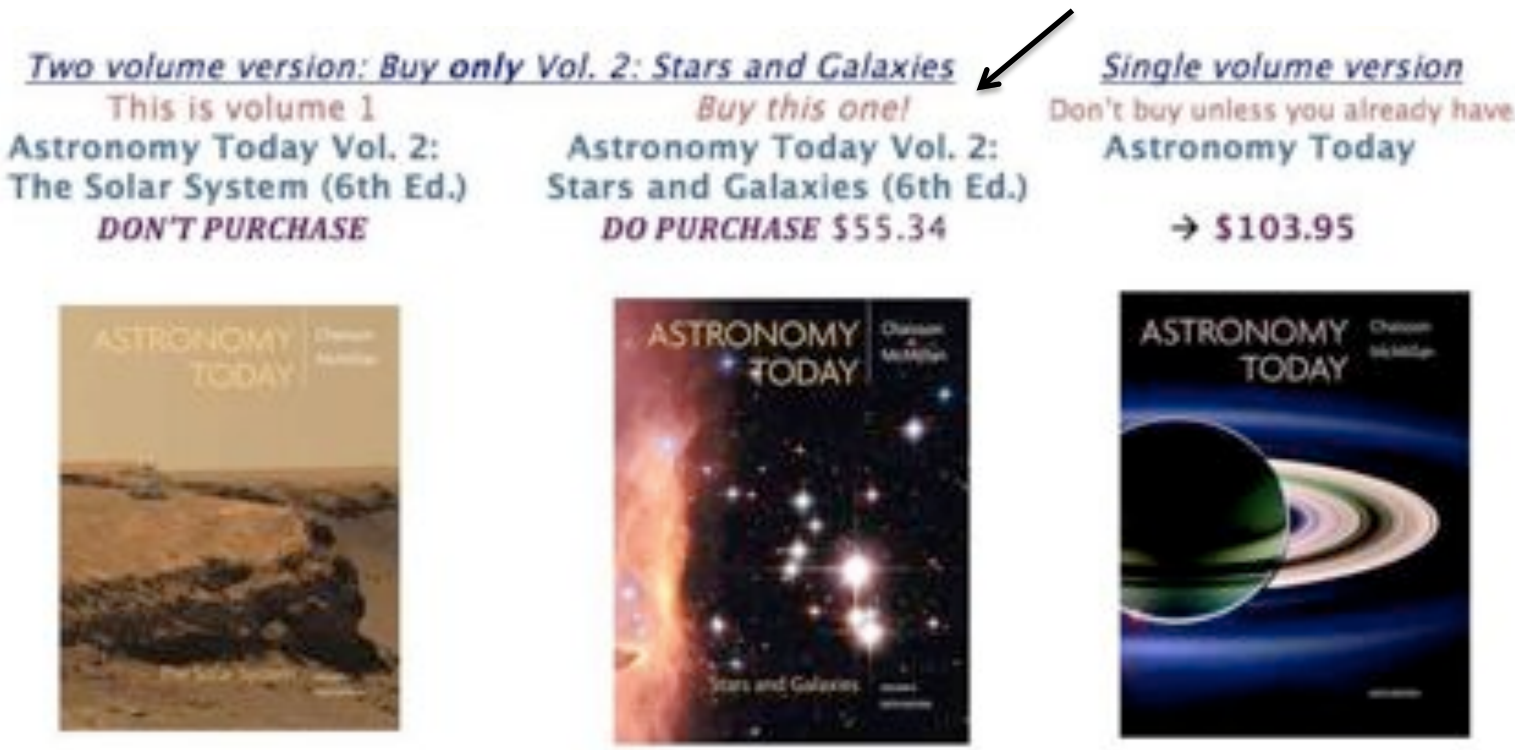
These are important to become familiar with NOW.

Then we get to the "real" material, starting with only a little history, leading to the motions of objects moving under the force of gravity—Kepler's laws, Newton's laws.

Buying and using the right version of the textbook

Our textbook is called Astronomy Today, by Chaisson and McMillan, and is in its **6th edition**. You *must* purchase the 6th edition—all others are out of date (or 7th edition) and have different section numbers, etc.

The textbook comes in two *versions*: a **single-volume,** very expensive hardback (the bluish-black book shown near the bottom of the page), or the same book divided into two volumes (the reddish-brown books shown). **We are using Volume 2 only.**



Some Important Introductory Concepts:

(1) Scientific notation.
(2) Adjusting to strange units.
(3) Distances, angles, sizes in astronomy.

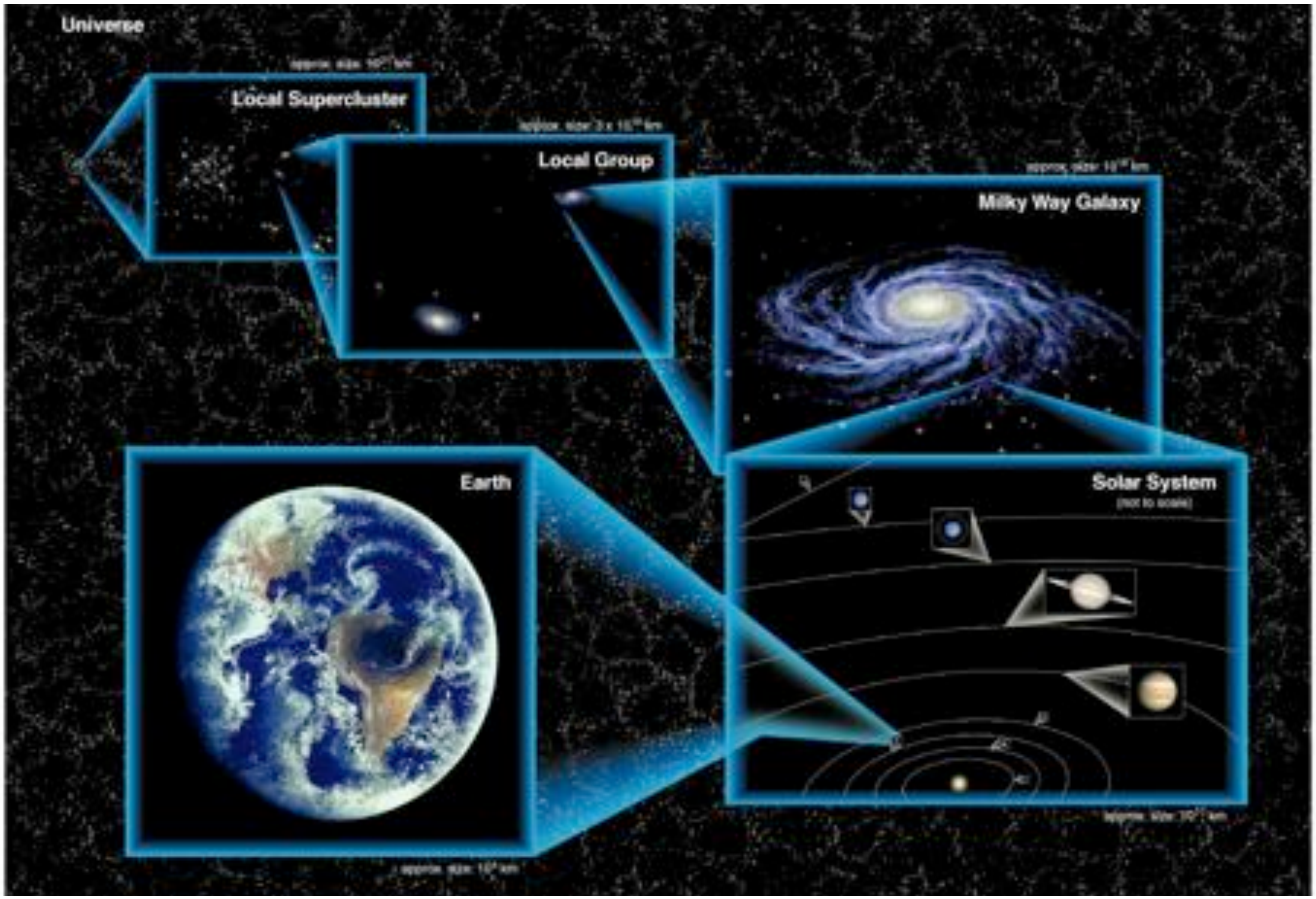
If you don't become comfortable with these preliminaries, you may have difficulty reading the textbook and understanding the lecture material.

As you skim your book for the first time, notice the huge range of scales that you will encounter for everything, from atoms to planets to galaxies to the observable universe. We need a convenient way to refer to the numerical values of their properties.

FIRST: Avoid writing lots of zeros. **Scientific notation** for very large and small numbers (**read Appendix 1** in text)
Example: 3×10^6 = 3 million, 4×10^{-3} = 0.004.

You will continuously encounter this notation in the textbook, so become comfortable with it now (even though I will not ask you to manipulate such numbers on exams). Just get used to it—try writing down a few yourself—e.g. two million, 3 one-thousandths, …

Range of size scales in the universe requires the use of a variety of **units of distance** --kilometer (km), astronomical unit (AU), parsec (pc), kiloparsec (kpc), megaparsec (Mpc)



Units of length, size, mass, … *Defined just for convenience*

➞ Units we use in measuring *anything* are just for convenience. You don't give the distance from Austin to New York in inches, or your age in seconds, or your height in miles.

Example: For distance or size, we could use "microns" for light waves or for dust particles, "centimeters" or "inches" for everyday objects, "light years" or "parsecs" for stars, "megaparsecs" for galaxies. This is nothing more than defining a unit that is about unity for a typical object you are talking about.

➞ Keep thinking about it for a while and soon it will be second nature.

It will help if you associate each new unit with some object--e.g. a "micron" is 0.0001 cm, but you don't need to know that, only that it is like the size of a microscopic dust grain.

Appendix 2 in the textbook goes over some of this; just skim it now and use it for future reference if you become confused about units. We will only be using a few units in this class, so it shouldn't cause any problem.

Another (important) example: it is convenient to state the masses of astronomical objects in units of the Sun's mass, e.g. "200 solar masses" or "200 M_{sun}" instead of writing "4 x 10^{35} grams." The masses of many galaxies (including our own) are in the range 10^9 to 10^{12} solar masses, so you can see there is no escaping scientific notation, even if we use a convenient unit. The range of properties of astronomical objects is just too large.

➞ *What unit would you use to express the mass of the planets in our solar system?*

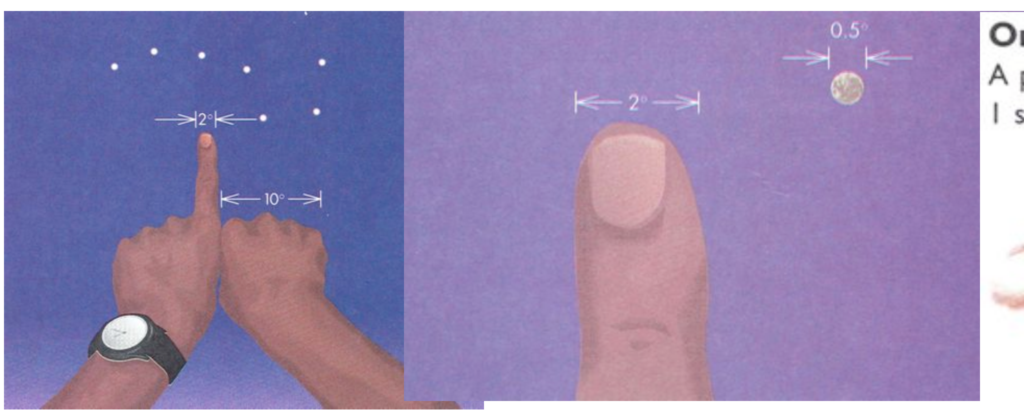
Angular measure – degree, arcminute, ***arcsecond*** (especially important).

This is usually the most difficult kind of unit for students to get used to. [See box p. 11]
➙ Angular measure using "*arcsecond*" terminology will occur in many places throughout the course (first in connection with "parallax").

Most astronomy today commonly breaks the "arcsecond barrier" imposed by our own Earth's atmosphere. (This effect, called "*scintillation*," is due to the turbulence in the Earth's atmosphere, which makes stars "twinkle.")

➙ *The term for the smallest angular size at which you can distinguish objects is called "**angular resolution**," a phrase you will encounter frequently!* **Get used to it now!**

You can remember what **resolution** means by keeping in mind that poor resolution is like being very nearsighted—everything looks blurry ➙ "*you can't resolve it*"



One Second of Arc
A penny at a distance of 4 km (2.5 miles) has an angular diameter of 1 second of arc.

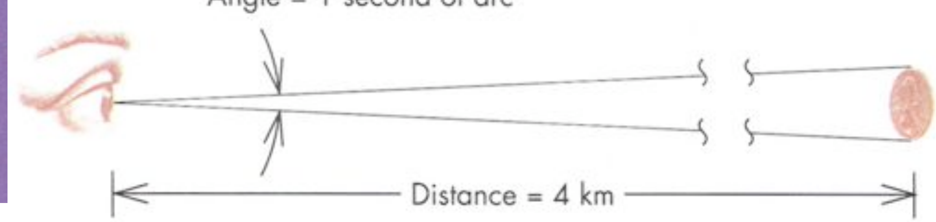
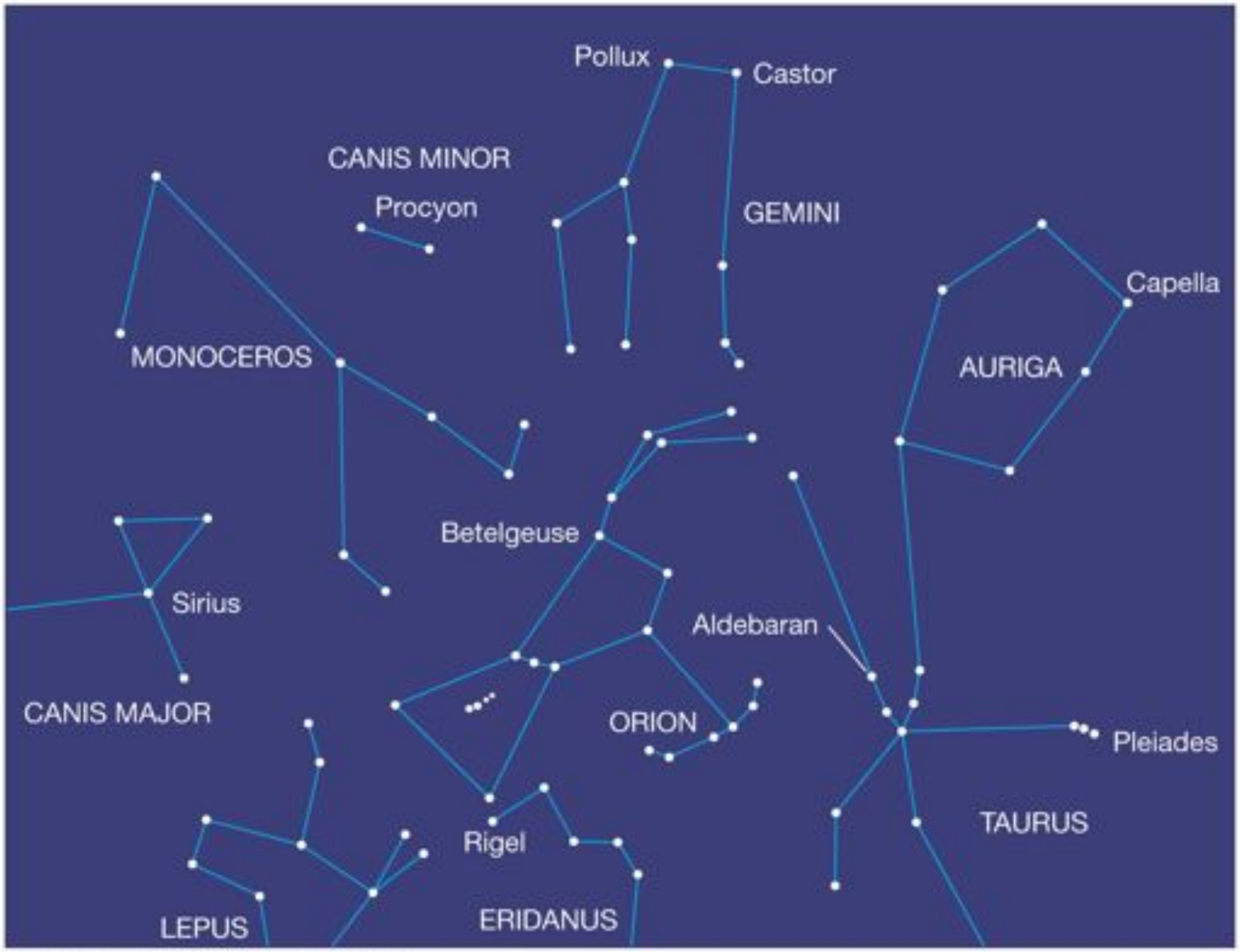
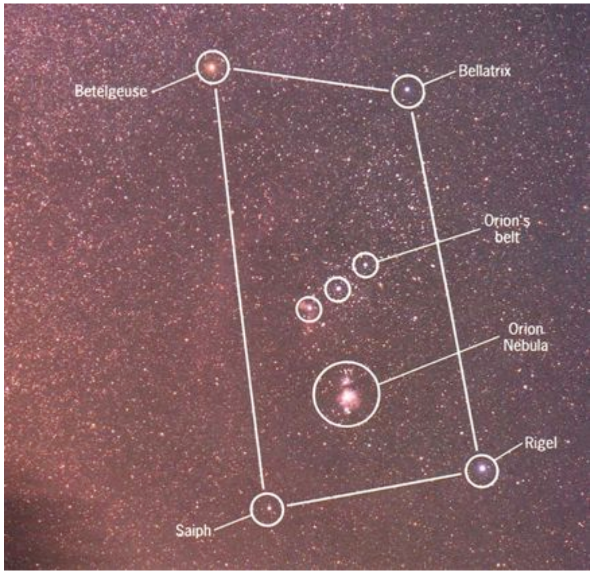


Figure 1.10

Constellations: meaningless but convenient



Constellations: These are just apparent groupings of stars in the sky; they are (usually) not physically associated, and could be at *very* different distances (see Orion example).



This is the constellation Orion as it appears in the sky.

This shows how the stars in Orion are really distributed in space

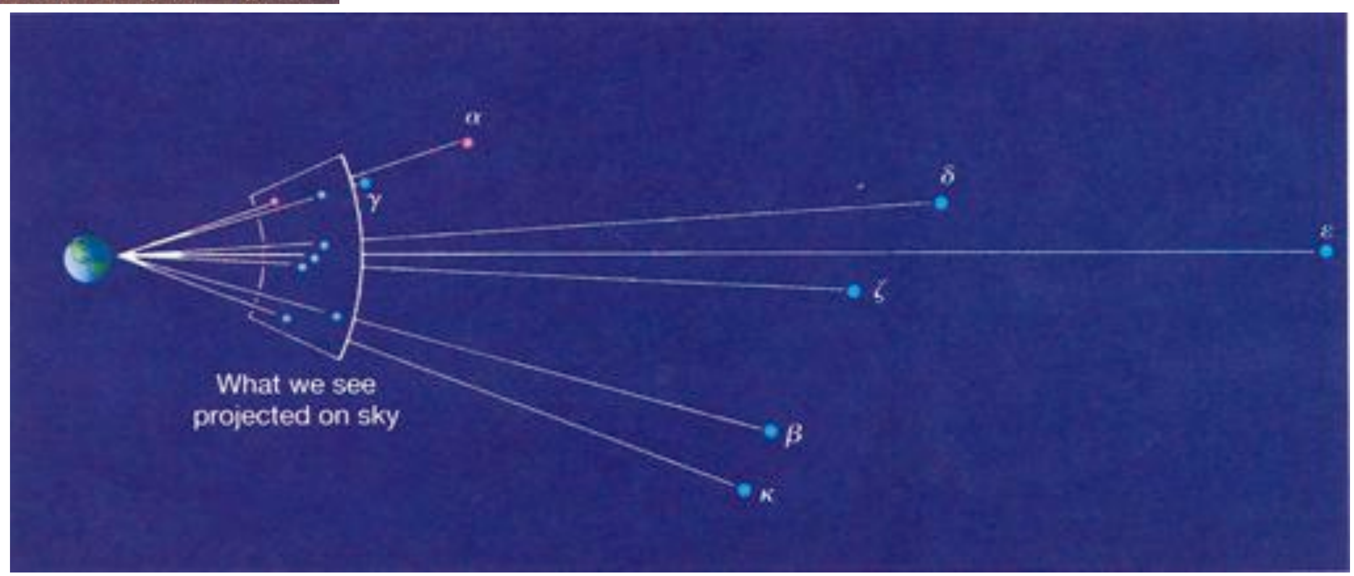
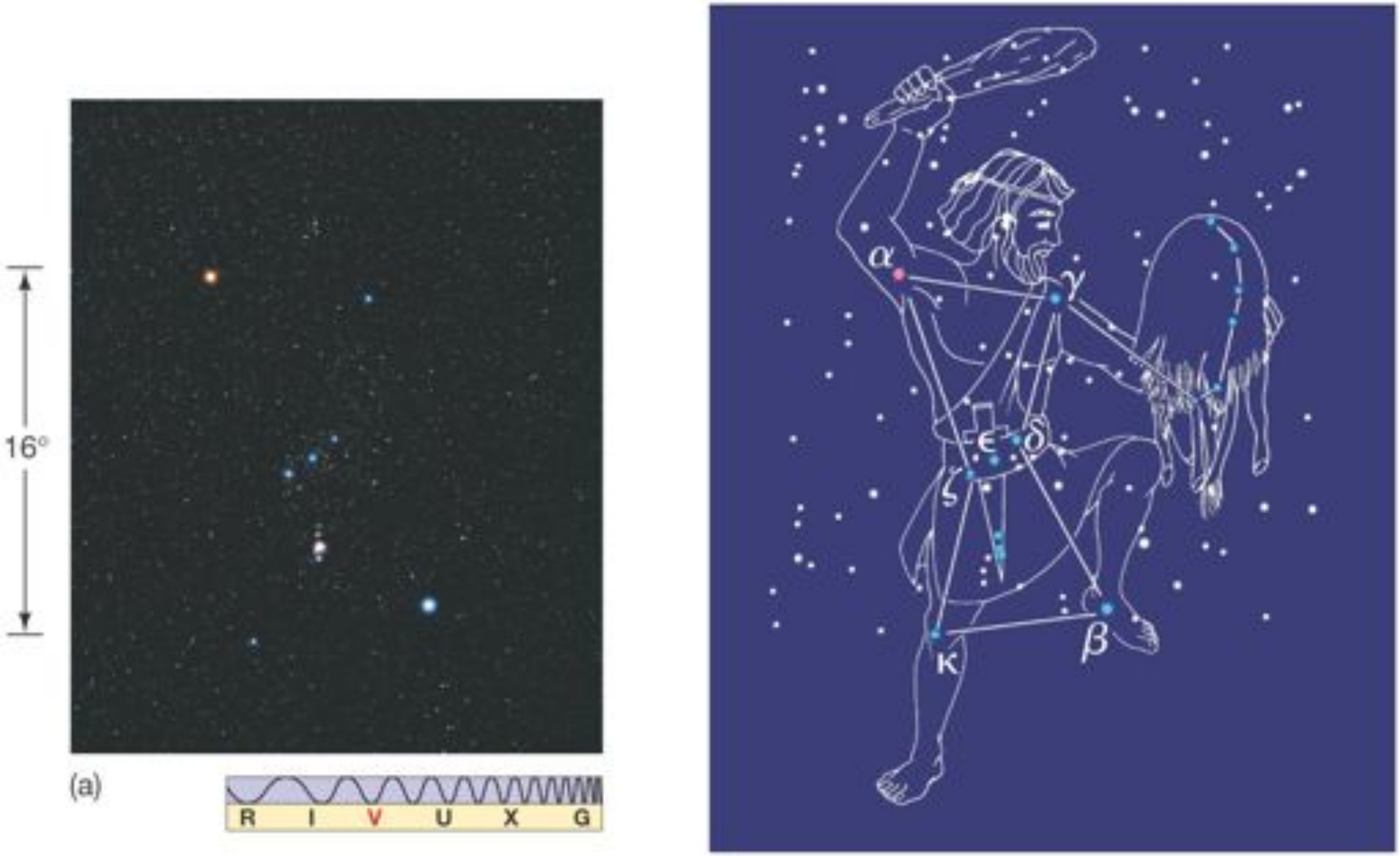


Figure 1.8



(a)

(b)

So far: Preliminaries; large and small numbers (scientific notation);
sizes and distances in the universe; constellations.

This time:

Relation between angular sizes and physical sizes.

Angular resolution.

Parallax and distances to stars (or anything)

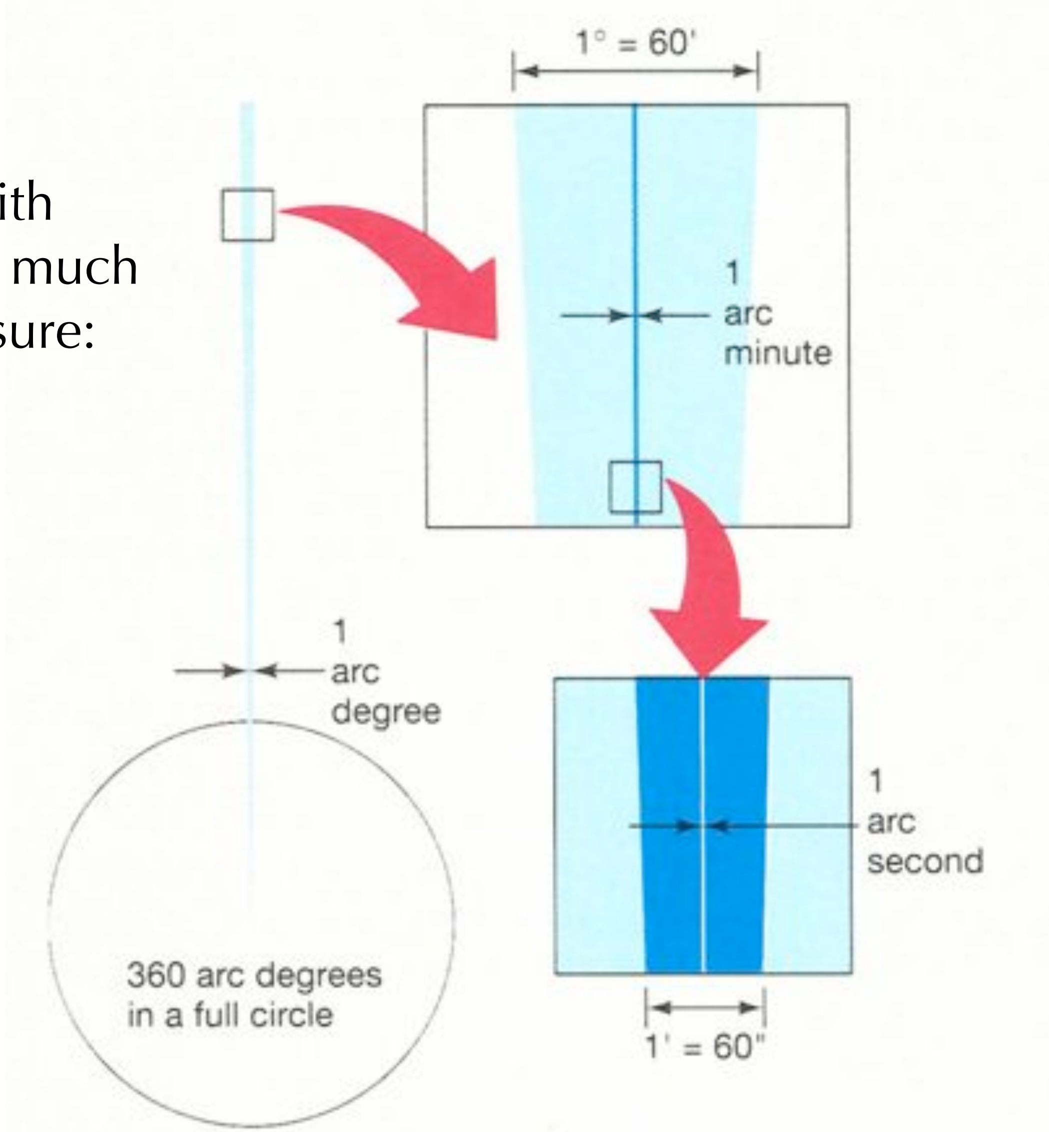
Heliocentric versus Geocentric view of the universe

Kepler's laws: How they allow us to calculate either the size of an object's orbit (its semimajor axis) or its period (how long it takes to orbit once).

Next: The more fundamental "laws": Newton's laws (Wednesday).

Angular measure--illustration from your textbook.

You are probably familiar with degrees. Now get used to a much smaller unit of angular measure: the *arcsecond*.



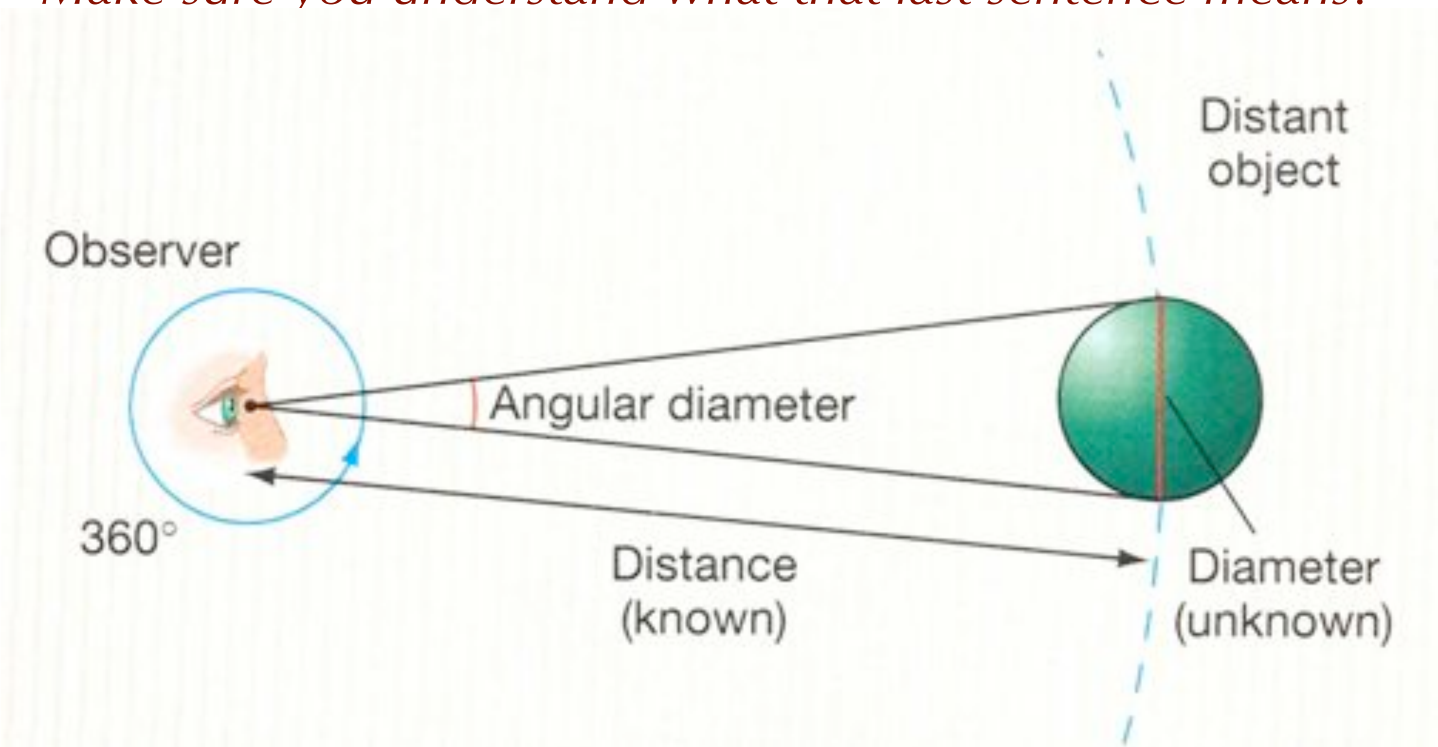
Angular diameter of an object --notice how you could get the distance of the object if you knew its size, or its size if you knew its distance.

Think about this until it seems obvious.

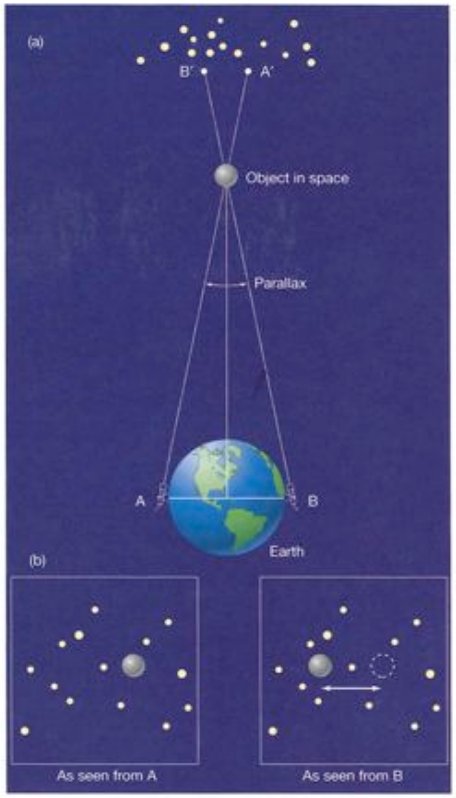
The formula is that **diameter = distance x angular diameter** (in "radians")

But if you can't "resolve" the object, then you can't use this method at all (e.g. for stars).

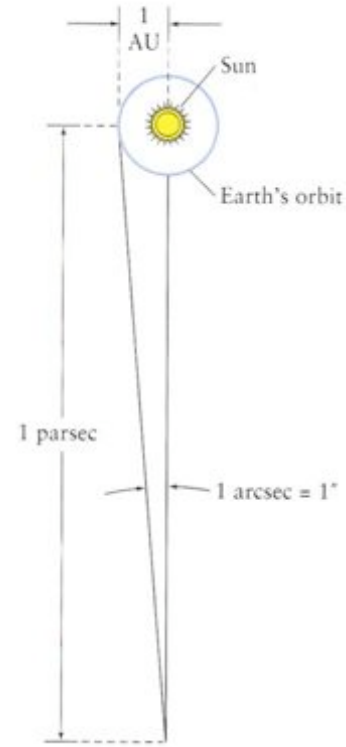
Make sure you understand what that last sentence means!



Distances from **Parallax** Angle (sec. 1.7 in text)



▲ **FIGURE 1.31** **Parallax** (a) This imaginary triangle extends from Earth to a nearby object in space (such as a planet). The group of stars at the top represents a background field of very distant stars. (b) Hypothetical photographs of the same star field showing the nearby object's apparent displacement, or shift, relative to the distant, undisplaced stars.



A Parsec The parsec, a unit of length commonly used by astronomers, is equal to 3.26 light-years. The parsec is defined as the distance at which 1 AU perpendicular to the observer's line of sight subtends an angle of 1 arcsec.

Left: Parallax using diameter of Earth. Understand why baseline is too small for stellar distances.

Right: Parallax using 1AU defines the unit of distance called a "parsec" (for distance of object whose **par**allax is one **sec**ond of arc (one arcsec). This is abbreviated pc, as in "That star is 6.3 pc away."

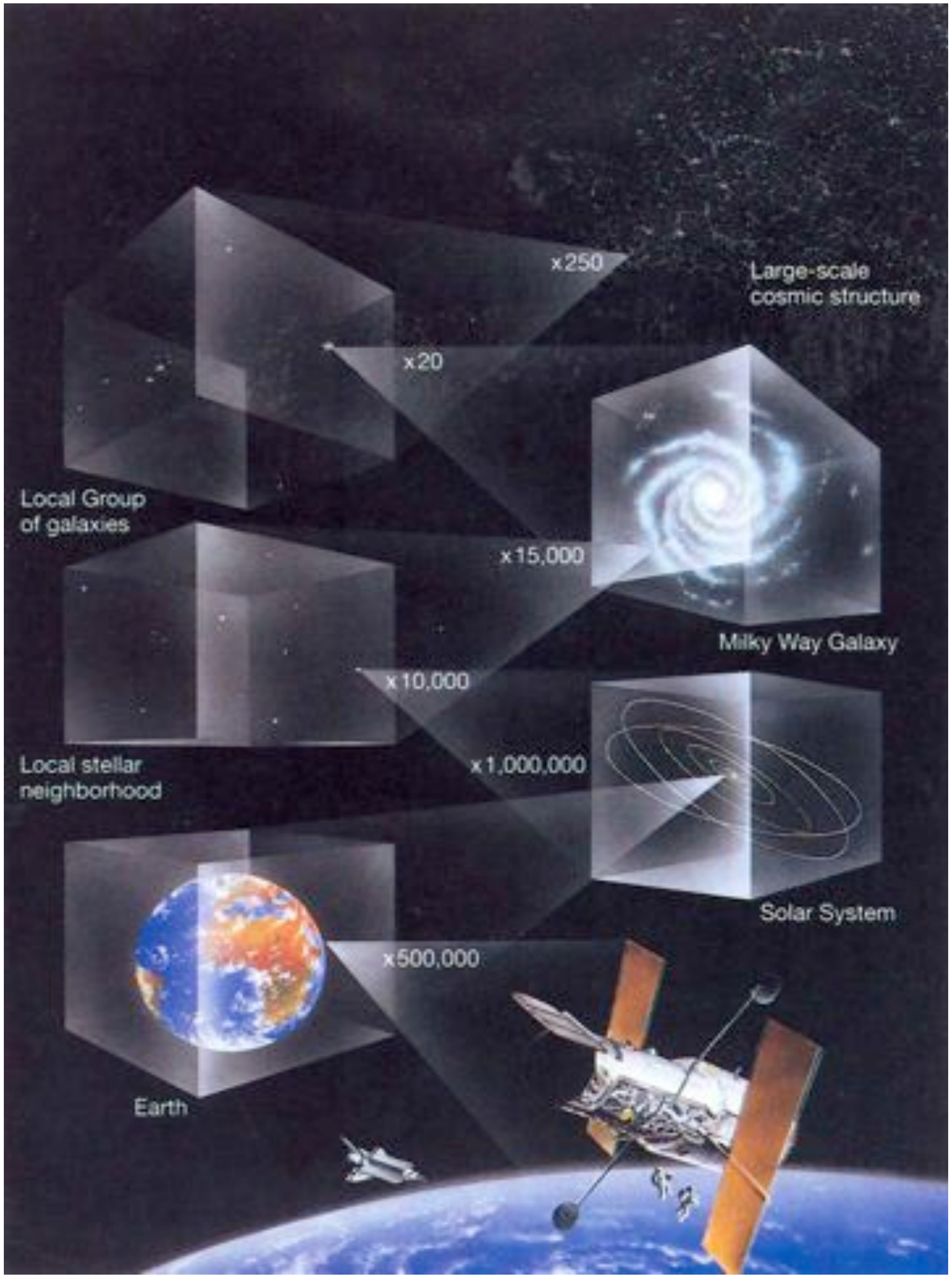
Distances and sizes in the universe

The measurement of distances to stars by parallax is the first step in a long line of methods to learn about the scale of the universe at larger and larger distances.
Can you explain why distances are so important to astronomy?

➡ Can only use *parallax* for nearest stars ~ few 100 pc, because stars more distant than that have parallaxes so small that they can't be measured (yet), even from space. Be able to explain this!

What we end up with is an amazing range of sizes and distances of various objects in the universe, as shown in the illustration to the right (from your text; good idea to stare at it a while).

But parallax is only the first step… (we'll take this up repeatedly throughout the course)

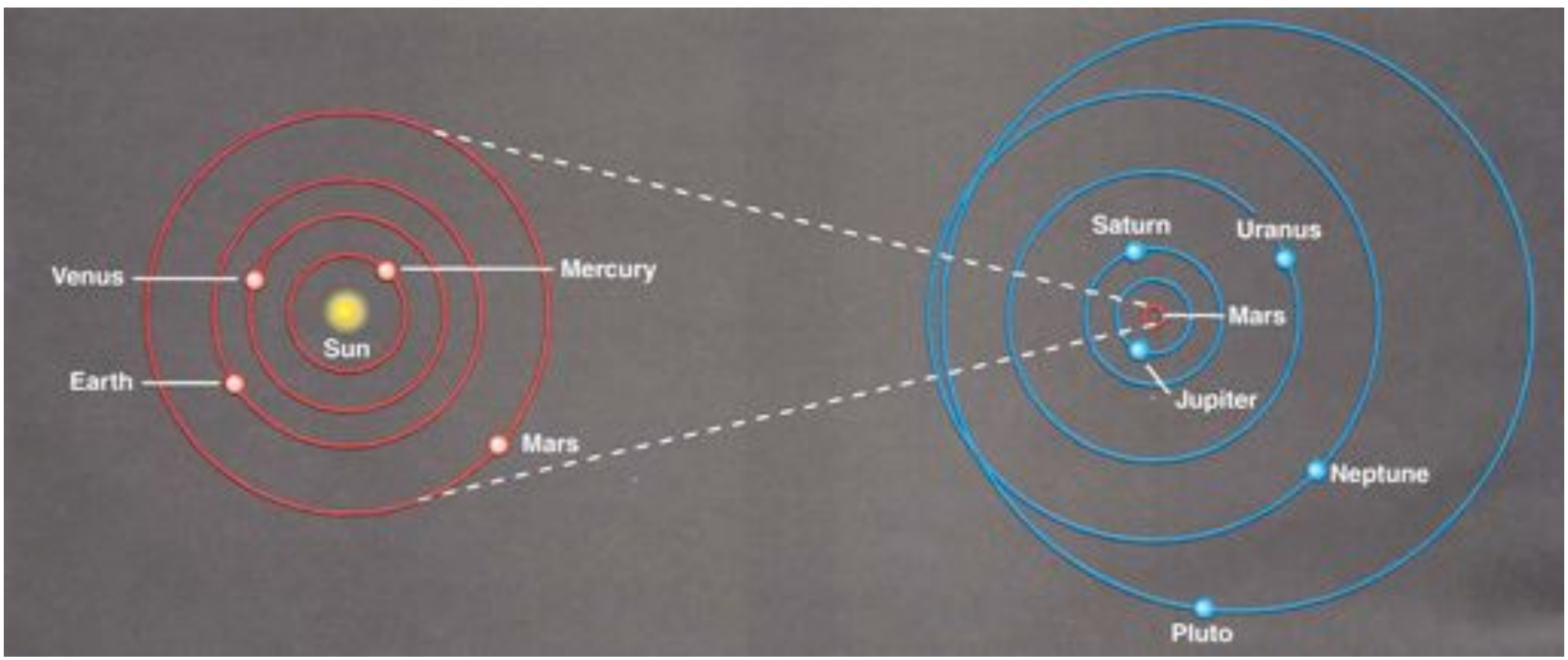


Distances: We'll return to parallax in more detail later in the course: for now you should just get the basic idea, and how it relates to the unit of distance called "***parsec***."

→ **Nearest stars** are about 1 pc (a few light years) away. This is also the average distance between neighboring stars in most galaxies. **It is a number that you should remember.**

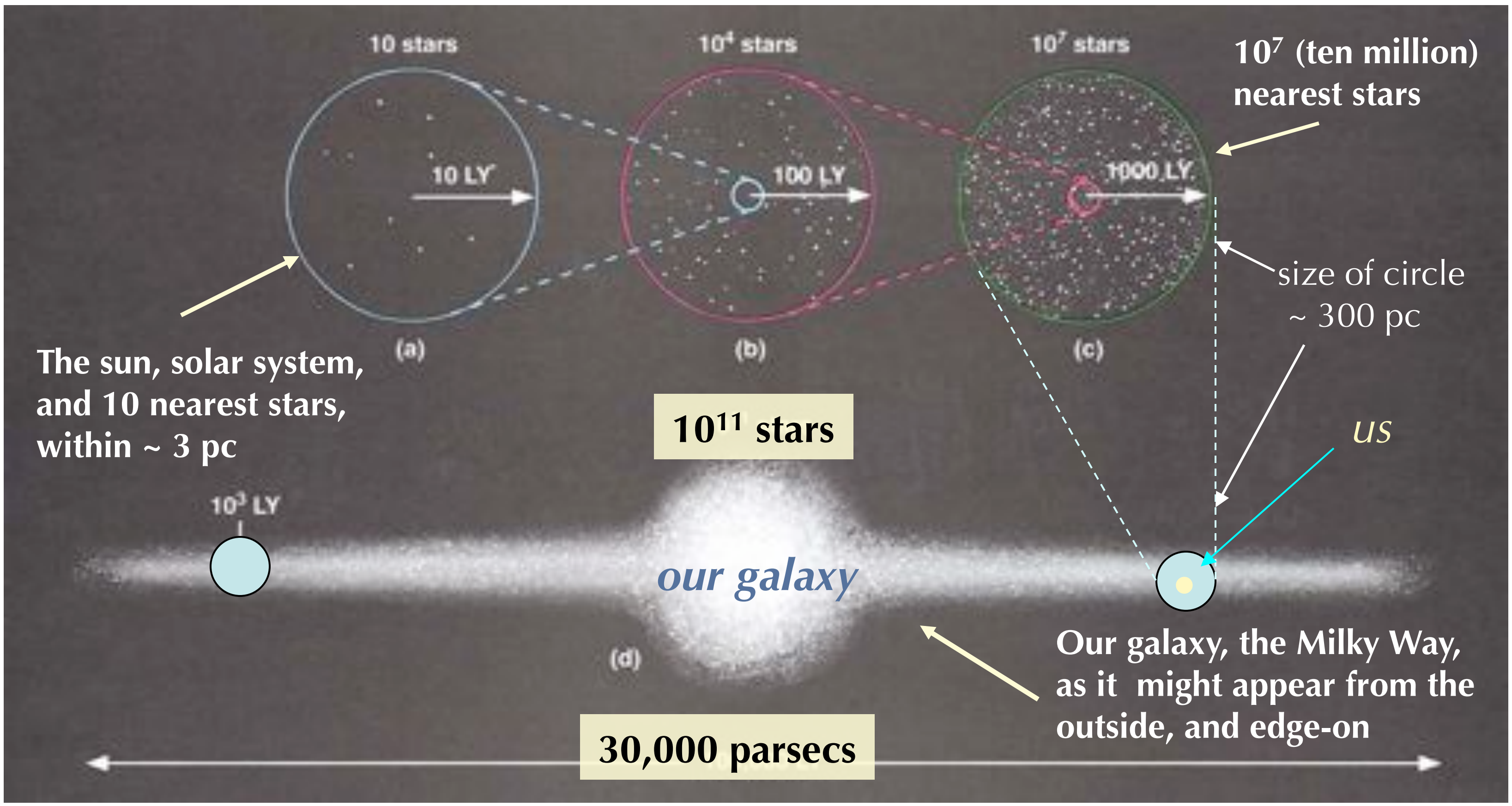
→ **Size of our Galaxy** and many others is about 10,000 pc, and the distances between galaxies range from millions (Mpc) to billions of pc (1000 Mpc—make sure you are comfortable with what this means--see preceding figure again).

→ For distances in the solar system, see sec. 2.6. Average distance from Earth to Sun defined as "***astronomical unit***" (1AU) (~ 10^{-3} pc), size of our solar system ~ 100 AU.
See picture below. *Remember, this is just for convenience, and is completely arbitrary.*



As we move out from the solar system to see the nearest stars, the scale of distances expands enormously--100AU is *tiny* compared to the average distances between stars, and nearly infinitesimal compared to the sizes of galaxies or larger structures in the universe.

Study this illustration until you can explain these distances to someone else.



End of "units"

Next: *Kepler's "laws"* and then, most importantly,
Newton's three laws of motion, and his *law of gravity*.

For next class, you should have finished reading the textbook through Kepler's laws and Newton's laws.

All the remaining material through chapter 3 will make much more sense if you realize at this point that most of what we are able to do with respect to astronomical objects is:

a. Watch them orbit around each other--this is why we need Kepler's and Newton's laws
b. Analyze the light we receive from them--this is why there are two chapters on what you can learn from the light you receive from something, even though you can't *resolve* its structure.