Astronomy & Space Physics: Some Important Concepts and Numbers

A Few Words of Introduction:

Before we talk about what this class is all about, let's clear up some misconceptions that many students have about astronomy.

Things that you won't learn about in Physics 111:

UFO's! (Unidentified Flying Objects)
(But, what about Extraterrestrial life, intelligent or not?
Oh, OK, sometime this semester we might see this NOVA episode!)

Astrology! *(If I hear you refer to this course as "Astrology",*
I'll give you minus 2 points extra credit!)

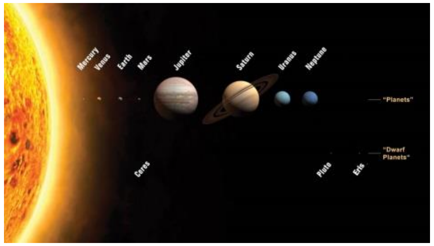
How to find constellations and other objects in the sky.

How to use a telescope.

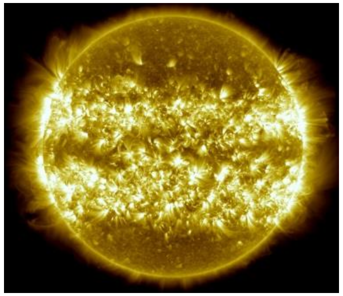
More Introduction

Some things that you will learn in Physics 111:

(in the form of questions that we will answer)



- What are the planets like and how did they get that way? Are there other planets orbiting other stars; how did we find that out, and what do we know about them?



- What is a star? Where does its energy come from?

- How do stars form, live out their lives, and die?

- What is the structure of the entire Universe? Where did it come from? What is it composed of? Are there other Universes?

- What can science say about extraterrestrial life?

Some Numbers & Scientific Notation

The most common question in the first week of Physics 111 is this:

Is there any Math in Physics 111?

Answer: **Yes and No**. We must be quantitative and be able to understand graphs, but there will be nothing beyond very simple algebra.

New Units for Distance:

In astronomy, distances are tremendously large, and common units of measurement, e.g. miles or kilometers can become cumbersome to use. So we frequently define new distance units – or yardsticks – two important ones are the **Astronomical Unit** and the **Lightyear**:

Some Numbers & Scientific Notation

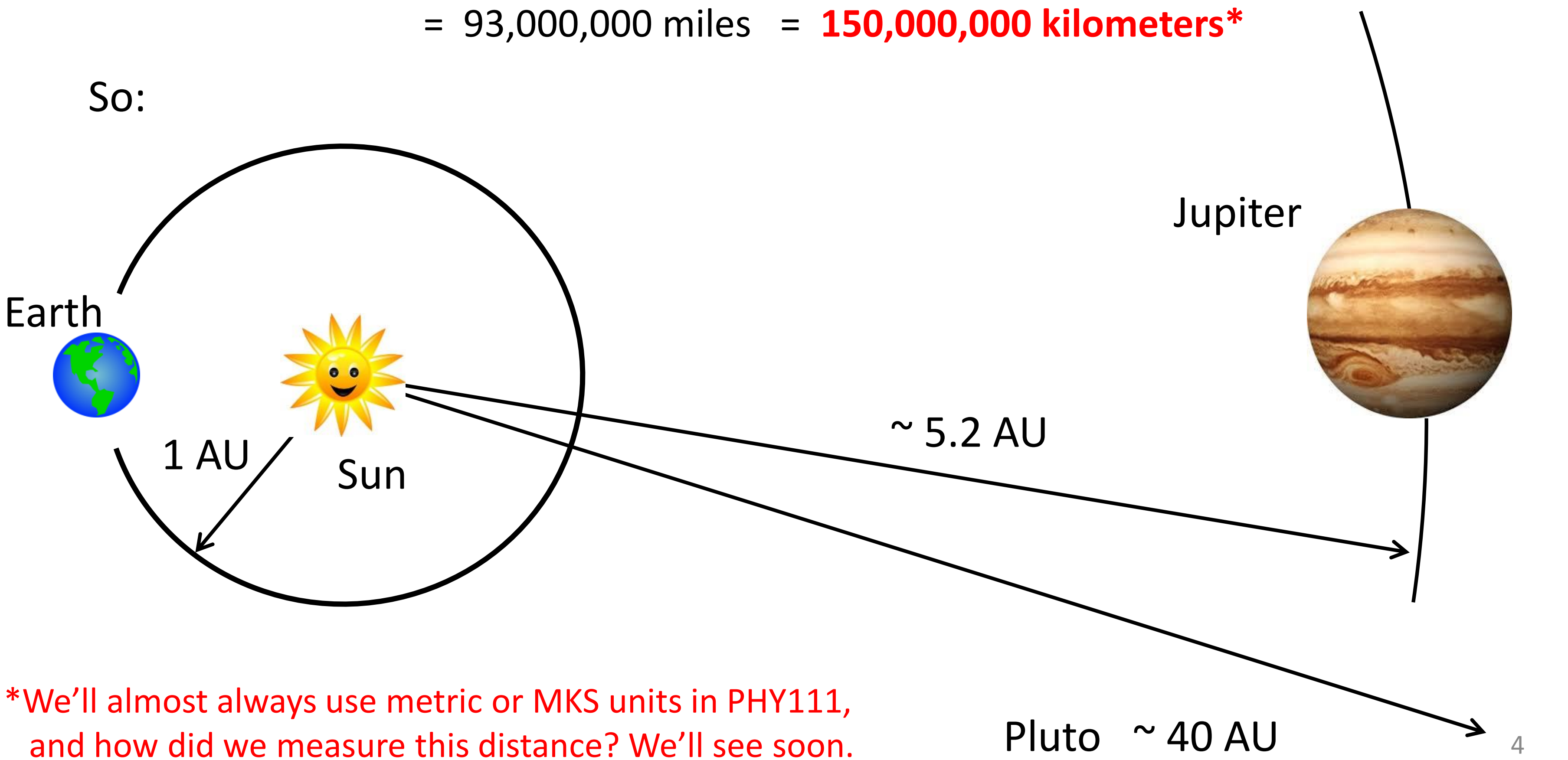
The **Astronomical Unit** (abbreviated AU, pronounced ay-u)is a convenient yardstick when we are inside the Solar System.

(note scale)

1 AU = Average distance between the Earth and the Sun

= 93,000,000 miles = **150,000,000 kilometers***

So:



*We'll almost always use metric or MKS units in PHY111, and how did we measure this distance? We'll see soon.

Some Numbers & Scientific Notation

Scientific Notation*:

Scientific notation (powers of ten) is very useful for expressing both large and small numbers. I'm assuming that you have seen it before.

Some Examples:

e.g. a large number:

Radius of the Earth = 6,370,000 m $= 6.37 \times 10^6\ m$

$$\text{where } 10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10$$

e.g. a small number:

Radius of a hydrogen atom = 0.0000000000529 m $= 5.29 \times 10^{-11}\ m$

$$\text{where } 10^{-1} = \frac{1}{10} \Rightarrow 10^{-2} = \frac{1}{10} \times \frac{1}{10}$$

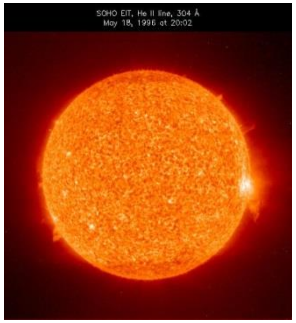
*You might want to review the material in Appendix C.1 and C.2 in your text.

Some Numbers & Scientific Notation and LC

A Real Example (LC) :

$$\text{Mass of the Sun, } M_\odot = 2.0 \times 10^{30}\ kg$$

$$\text{Mass of a proton, } m_p = 1.67 \times 10^{-27}\ kg$$



Work together with the people sitting around you and **find an estimate for how many protons are in the Sun (to within a factor of . . . say 10)**. **At the LC prompt, enter your answer into Learning Catalytics.**

How do you do this?

Assume: The Sun is made of all hydrogen (not really, but close enough), and proton mass >> electron mass. So:

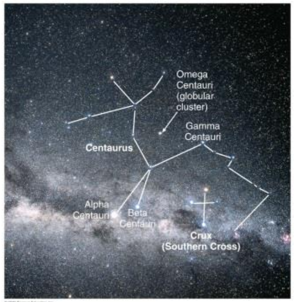
$$\text{Number of Protons} \approx \frac{M_\odot}{m_p} = \frac{\cancel{2} \times 10^{30}}{\cancel{1.67} \times 10^{-27}} \approx 1 \times 10^{30-(-27)}$$

$$= 1 \times 10^{57}$$

close enough

Some Numbers & Scientific Notation

For distances beyond the Solar System, we introduce a new yardstick:



e.g. **What is the distance to the nearest star?**
(In a few weeks, we'll discuss how this is measured.)

$$\sim 300,000\ AU = 3 \times 10^5\ AU$$

Define: **1 Light Year (ly)** = **Distance** that light travels in a time of 1 year.

How far is this?

$$\text{speed of light, } c = 3 \times 10^5\ km/s$$

$$\text{distance} = \text{speed} \times \text{time}$$

$$1\ ly = (3 \times 10^5\ km/s)(1\ y)(\sim \pi \times 10^7\ s/y)$$

$$\approx 9 \times 10^{12}\ km \approx 60,000\ AU$$

So, the distance to the nearest star ~ 5 ly

(powers of 10: old, new, and fun)

<u>Angular Measure</u>

In astronomy, we use **angles** to locate objects in the sky and to describe the size of extended objects as seen from the Earth.

Angular units widely used in astronomy are:

<u>Degrees, Minutes, and Seconds of Arc:</u>

$$1 \text{ degree } (1^\circ) = \frac{1}{360} \text{ of a full circle}$$

$$1 \text{ arc minute } (1') = \frac{1}{60} \text{ of a degree}$$

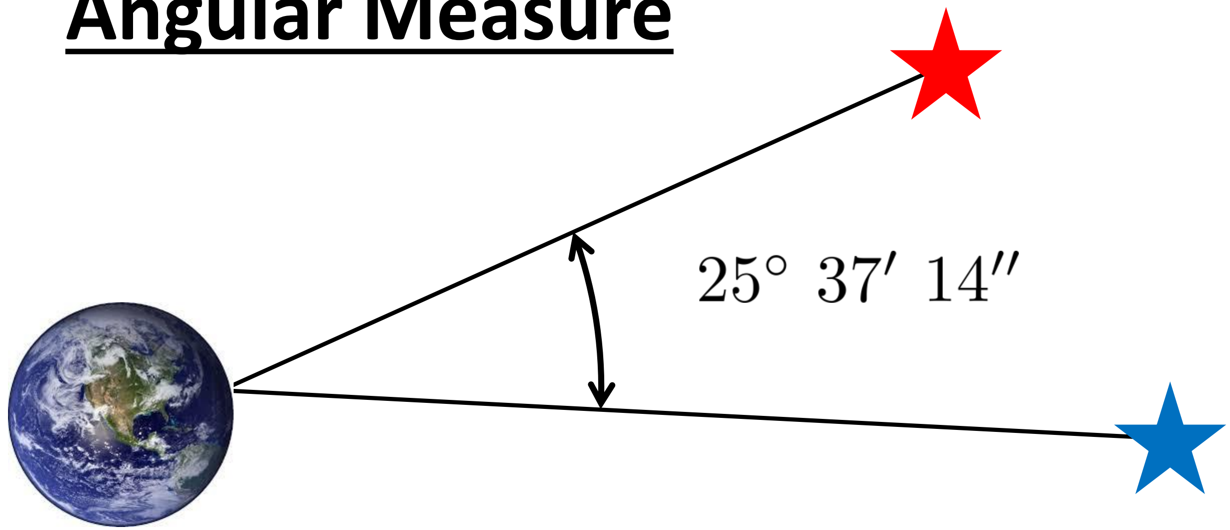
$$1 \text{ arc second } (1'') = \frac{1}{60} \text{ of a minute}$$

<u>So</u>: Minutes and seconds of **arc** have the same relation to a degree that minutes and seconds of **time** have to an hour.

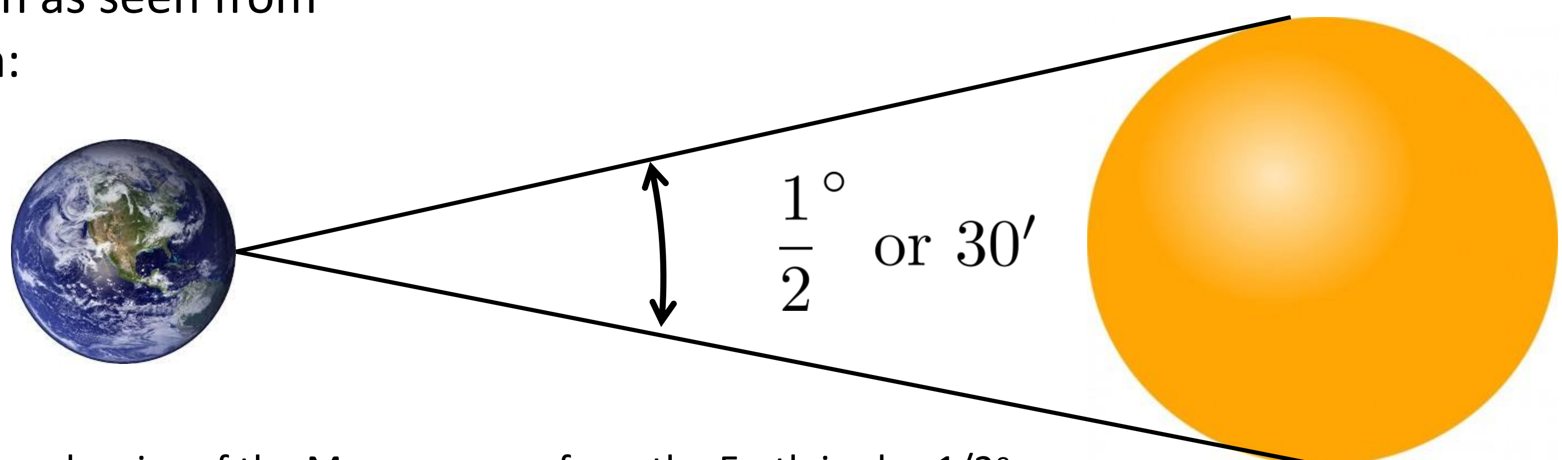
Angular Measure

For example:

We might report the angle between two stars as seen from the Earth:



Or, the angular size of the Sun as seen from the Earth:



Note: the angular size of the Moon as seen from the Earth is also 1/2°
. . . That's what makes a total solar eclipse so spectacular; we'll cover eclipses soon.

Some Philosophical Considerations

What is the study of astronomy?

Astronomy can mean many different things to different people.
We'll come back to this question on the last day of class.

Why are we here, i.e. in this class? . . . *and let's all be totally honest:*

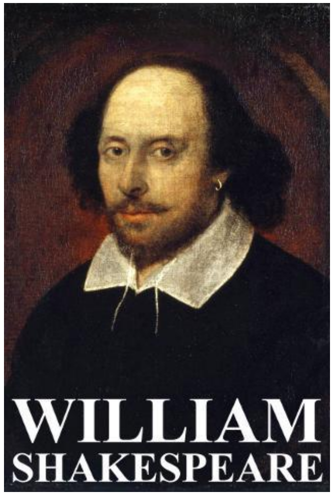
Why are you here? (LC) *Probably to fulfill the requirements of the Miami Plan; so that you can graduate.*

Why is Dr. Alexander here? (LC) *They pay him to do this! (although he does love it!)*

But, is there more to it than that?

Where's one place to seek out philosophical guidance for the reasons that we do what we do in life? **(LC)**

Perhaps:



Some Philosophical Considerations

What does Shakespeare's Hamlet have to say? *(listen carefully)*

Did you catch that? Here's what Hamlet said:

What is a Man,
If his chief good and market of his time
Be but to sleep and feed? A beast, no more.
Sure, he that made us with such large discourse,
Looking before and after, gave us not
That capability and god-like reason
To fust in us unused.

watch again

William Shakespeare, Hamlet, IV, iv

So, according to Shakespeare, we may live out our lives with success and honor (dare I say, "love and honor"), but if we make no attempt to understand this vast and mysterious Universe in which we find ourselves, we have, in a large sense, wasted our time and God-given talents!