<h1 style="text-align:center">Key Ideas to Measuring Very Large distances</h1>

Distance is the most important & most difficult quantity to measure in Astronomy

Units of Distance used in astronomy:

Astronomical unit…the average distance between the Earth and the Sun
149,597,870,700 meters 149,597,870.700 kilometers
(92,955,807.273 miles)

Light Year…how far light travels in a single year
Light second…how far light travels in a second ~300,000 kilometers
Can you figure out how far light travels in one year?

Parsec (**Par**allax **sec**ond)… Fundamental unit of distance in Astronomy
"A star with a parallax of 1 arcsecond has a distance of 1 Parsec."
1 parsec (pc) is equivalent to:

206,265 AU
3.26 Light Years
3.086×10^{13} km (and that's a big distance!)

So what is an Arcsecond (also called a second of arc)

Well its based on the sexagesimal system of angular measurement. If you are familiar with a circle having 360 degrees then you can see how the

Unit	Value	Symbol	Abbreviations
Degree	$\frac{1}{360}$ circle	°	deg
Arcminute	$\frac{1}{60}$ degree	′ (prime)	arcmin, amin, am, ′, MOA
Arcsecond	$\frac{1}{60}$ arcminute	″ (double prime)	arcsec, asec, as
Milliarcsecond	$\frac{1}{1,000}$ arcsecond		mas
Microarcsecond	10^{-6} arcsecond		µas

arcsecond fits in.

<p style="text-align:center">**The sexagesimal system of angular measurement**</p>

A minute of arc, arcminute, or minute arc (MOA), is a unit of angular measurement equal to one sixtieth (1⁄60) of one degree (circle⁄21,600). ..if you are wondering how we got the 21,600 number in the denominator…1/60 of one degree of a circle means 1/60 x 1/360… so we multiply 60 x 360 = 21,600.

So… a second of arc or an arcsecond is one sixtieth (1⁄60) of one minute of arc. Since one degree is defined as one three hundred and sixtieth (1⁄360) of a rotation (a circle is a complete rotation) one minute of arc is 1⁄21,600 of a rotation. It is used in those fields which require a unit for the expression of small angles, such as astronomy, optometry, ophthalmology, optics, navigation and marksmanship.

**Why are Distances Important?**

Distances are necessary for estimating

> Total energy emitted by an object (Luminosity)
> Masses of objects from their orbital motions
> True motions through space of stars
> Physical sizes of objects

The problem is that distances are very hard to measure...

The problem of measuring distances

Question: How do you measure the distance of something that is beyond the reach of your measuring instruments?

Answer: You resort to using GEOMETRY to find the distance.

June

December

Foreground
Star
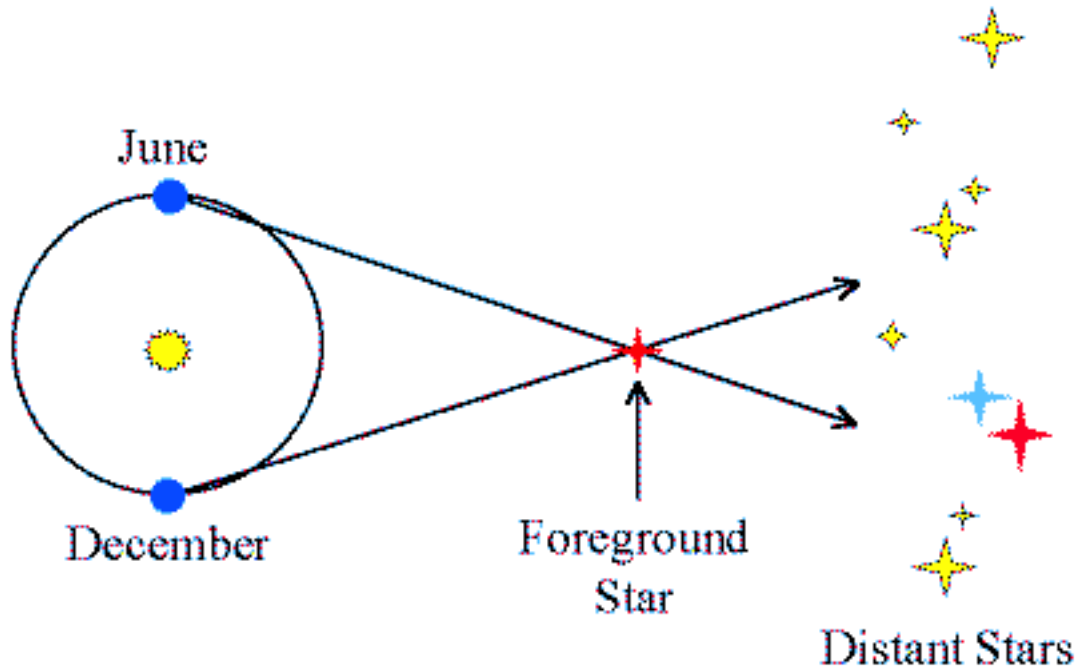
Distant Stars

**The Method of Trigonometric Parallaxes**

Nearby stars appear to move with respect to more distant background stars due to the motion of the Earth around the Sun. This apparent motion (it is not "true" motion) is called **Stellar Parallax**.

In the picture above, the line of sight to the star in December is different than that in June, when the Earth is on the other side of its orbit. As seen from the Earth, the nearby star appears to sweep through the angle shown. Half of this angle, is the parallax, **p**.

Parallax *decreases* **with Distance**

As the distance to a star **increases**, the its parallax **decreases**. This is easy to see in the following two figures:
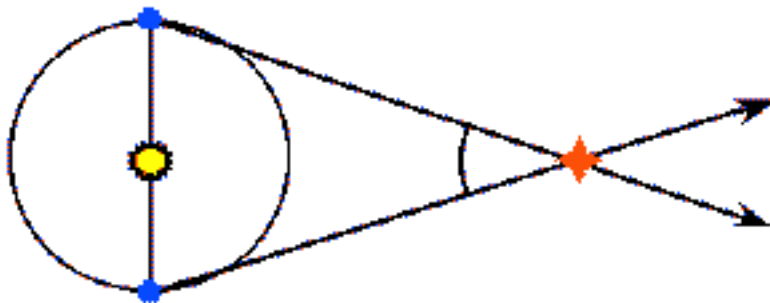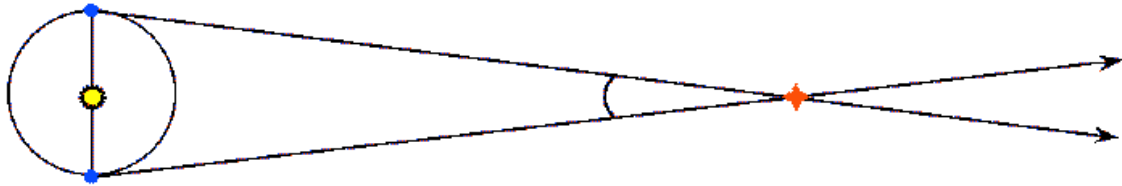
In the upper figure, the star is about 2.5 times nearer than the star in the lower figure, and has a parallax angle which is 2.5 times larger.

This gives us a means to measure distances directly by measuring the parallaxes of nearby stars.

We call this powerful direct distance technique the **Method of Trigonometric Parallaxes**.

Stellar Parallaxes

Because even the nearest stars are very far away, the largest measured parallaxes is very small; less than an arcsecond.

For example, the nearest star, Proxima Centauri, has a parallax of 0.772-arcsec (the largest parallax observed for any star).

We use photography and digital imaging techniques to measure parallaxes today. Increasingly, we measure parallaxes from space to avoid blurring due to the Earth's atmosphere.

So to Review:

Parsec

The Parsec is the fundamental unit of distance in Astronomy and a parallax of 1 arcsecond is called a Parsec.

"A star with a parallax of 1 arcsecond has a distance of 1 Parsec."

1 parsec (pc) is also equivalent to:

206,265 AU
3.26 Light Years
3.086×10^{13} km

Light Years

An alternative unit of astronomical distance is the **Light Year** (ly).
"1 Light Year is the distance traveled by light in one year."
1 light year (ly) is equivalent to:

0.31 pc
63,270 AU
The light year is used primarily by writers of popular science books and science fiction writers. It is rarely used in research astronomy.The reason is that the parsec is directly derived from the quantity that is being measured (the stellar parallax angle), whereas the light-year must be derived from having previously measured the distance in parsecs. In this way, the parsec is a more "natural" unit to use than the light yea