Parallax

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Grade: 100

Abstract	Excellent abstract – reads very nicely. I also like the extensive use of Greek letters!
Procedure	I really like how you begin to introduce the method of parallax with a simple diagram. Please use the tan command, rather than just tan so that the letters do not appear in italics. You also don't need all those par commands, just leave a blank line between paragraphs in your tex source file. I also really like your use of the numbered list to define your terms. One thing I would add would be to put each figure inside a figure environment.
Conclusion	Solid conclusion – and I like that you have subdivided things up. Try using the subsection* command rather than the bold and noindent stuff. Very fine report! I'm always excited to see what new LaTeX things you have figured out. Keep up the great work!

List of Comments

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Abstract

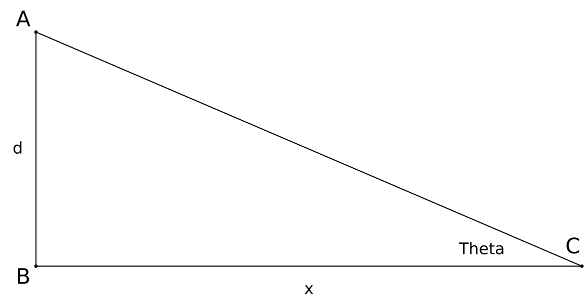
What is Parallax?

Parallax is a displacement or difference in the apparent position of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines (src: Wikipedia). It comes from the Greek word $\pi\alpha\rho\alpha\lambda\lambda\alpha\xi\iota\zeta$ (parallaxis), meaning alteration. It is also defined as the effect whereby the position or direction of an object appears to differ when viewed from different positions. While Parallax has multiple uses, the most common one is finding the distance to objects where we cannot measure length. In fact, astronomers use Parallax to find the distance to close stars from Earth. Other uses include: photogrammetric parallax, parallax error in photography, parallax in optical sights, artillery gunfire, and rangefinders.

Additionally, the parallax effect is used in many websites to create a stunning visual perspective effect. This is called parallax scrolling.

Procedure

Basic Model for Using Parallax to Calculate Distance



<u>In this diagram:</u>

Points A and **B** are two people

Point C is an object in the distance that Person A and Person B are observing

d is the distance between the people

x is the distance to the object being viewed from Person B

Theta (θ) is the angular difference of observation between the locations

To calculate the distance between Person B and the object, you first need to know d, the distance between Person A and Person B. Then, use the Tangent function:

$$tan(\theta) = d/x$$

Which can be rewritten as:

$$x = d/tan(\theta)$$

History of the Degree

The motivation for using the degree as a unit of angles and rotations is unknown, but there are many theories.

One theory is the fact that 360 is the approximate the number of days in a year. Ancient astronomers noticed that the sun seems to advance in its path by one degree a day.

Another theory is that the Babylonians subdivided the circle using the angle of an equilateral triangle as the basic unit and further subdivided it into 60 parts following their sexagesimal numeric system. The sexagesimal system is a numeral system using the number 60 as its base.

Conveniently, 360 is extremely divisible. It has 24 total divisors and is divisible by every number between 1 and 10, except for 7.

History of Stellar Parallax

According to Wikipedia, In 1729 James Bradley was the first to try to measure stellar parallaxes. However, the stellar movement was too insignificant for his telescope. Because of this experiment, he discovered the aberration of light the nutation of Earths axis, and catalogued 3222 stars.

In the 19th and 20th Centuries, the method of Annual parallax was discovered. Annual Parallax is normally measured by observing the position of a star at different times of the year as Earth orbits the sun. This was the first reliable way to determine the distances to the closest stars.

The first successful measurement of stellar parallax was made by Friedrich Bessel in 1838.

Problem

You are an astronomer for NASA and are tasked with finding the distance between Earth and Alpha Centauri (assume that previous astronomers have never calculated this distance). In this hypothetical world, Parallax is a recent discovery and astronomers have not found the time to calculate this distance. It is now your job to do so...

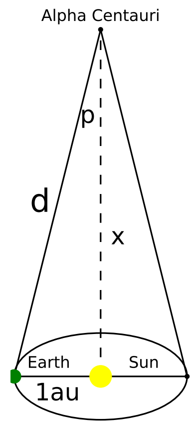
Before showing the steps to this problem, some terms need to be defined:

1. **arcsecond (as)**: a unit of angular measurement equal to 1/3600 of a degree. *This unit originated in Babylonian astronomy as sexagesimal subdivisions of the degree; they are used in fields that involve very small angles, such as astronomy, optometry, ophthalmology, optics, navigation, land surveying and marksmanship. (src: Wikipedia)*

2. **astronomical unit (au)**: a unit of length, roughly the distance from Earth to the Sun.

3. **parsec (pc)**: the distance to an object with a parallax of 1 arcsecond. *One parsec is the distance at which one astronomical unit subtends an angle of one arcsecond. (src: Wikipedia)*

You also know that the distance from the Earth to the Sun is $1.581e-5$ light years. Given that **1 light year = 0.306601 parsecs**, you calculate this distance to be approximately $4.8481e-6$ parsecs. In addition, you know that from Earth, the measurable parallax at an angle perpendicular to the sun is .7471 arcseconds, or .000208 degrees.



In the above diagram:

p is .000208 degrees
d is the distance from Earth to Alpha Centauri
x is the distance from the Sun to Alpha Centauri

To solve for **x**, use the derived equation from earlier:

$$x = (1au)/tan(p)$$

$$\downarrow$$

$$1\text{au} = 4.8481e - 6 \text{ pc} = 1.581e - 5 \text{ light years}$$

$$\downarrow$$

$$x = (1.581e - 5)/tan(.000208)$$

$$\downarrow$$

$$x = 4.366 \text{ light years} = 1.339 \text{ pc}$$

Now that you know the value of x, you can use the *Pythagorean Theorem* to solve for d (distance between Earth and Alpha Centauri):

$$a^2 + b^2 = c^2$$

$$\downarrow$$

$$x^2 + (1au)^2 = d^2$$

$$\downarrow$$

$$(4.366)^2 + (1.581e - 5)^2 = 19.061956$$

$$\downarrow$$

$$d^2 = 19.061956$$

$$\downarrow$$

d = 4.366 light years = 1.339 pc!

Conclusion

Summary

Parallax is the effect whereby the position or direction of an object appears to differ when viewed from different positions. It is used for many tools related to sight or vision, but it is used most by astronomers to calculate the distance to Earth's closer stars.

Problems With Parallax

While, parallax is extremely useful and gives us the ability to calculate distances we cannot physically measure, it has its limitations. First, using parallax to calculate distances is not possible if the objects are moving. You must make the calculation in one instant. In addition, parallax cannot be calculated with angles much less than one second of arc. This is because we do not have measuring devices capable of measuring such small degrees.

Other Limitations

Another limitation with parallax is that the angles measured are always small. According to the Australia Telescope National Facility, ”traditional ground-based optical observations also face the problems presented by observing through a turbulent atmosphere. These two factors combine so that the uncertainties in the measured values are very high for most stars.” **Until recently, these ground-based methods were restricted to a distance of around 40 pc.** Only a minuscule amount of stars had reliable parallax and distance measurements.

please use “these” for quotes so that you get an open and close quote.

Potential Solution

Because accurate distance measurements are essential for helping astronomers check stellar models, astronomers are always looking for accurate and precise distance values. One way to overcome the problems caused by the atmosphere is to get above the atmosphere. **This means calculating and observing from space.**