Science: Astronomy

Distance and Parallax

Objectives

Students will be able to:

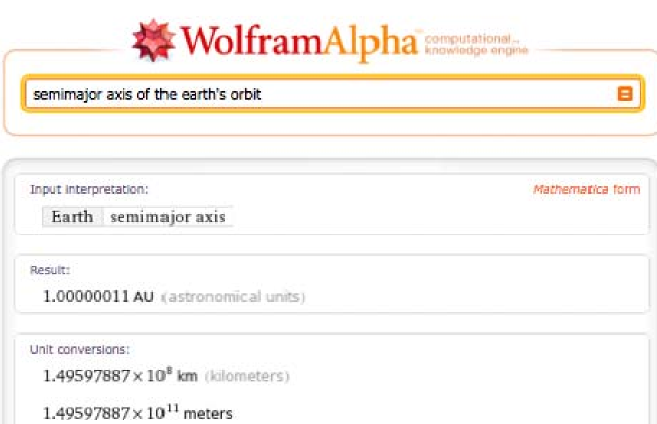
- Explain and illustrate the concept of parallax.
- Apply trigonometry to problem-solving.
- Use parallax to determine the distances to nearby stars.
- Evaluate the limitations of the parallax method.

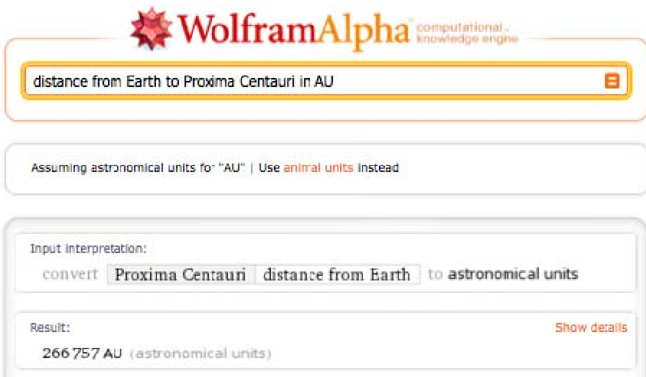
Warm-Up

Ask each student to hold his or her thumb up at arm's length, close one eye, and look carefully at the position of the thumb relative to the background. Then simultaneously open the closed eye and close the other; the position of the thumb relative to the background appears to change. This is the phenomenon of parallax, the apparent change in an object's position determined by the distance between observation points and the distance between the observer and the object.

Lesson

- Ask students to look up the semimajor axis of the earth's orbit and the accepted distance to the nearest star, Proxima Centauri, using W|A.

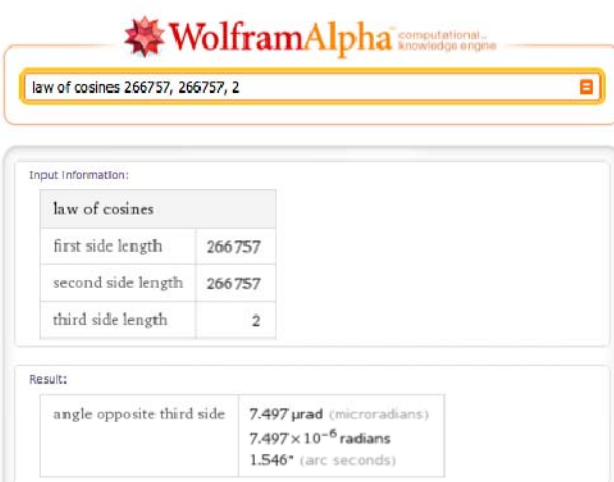




• Now ask students to sketch a diagram including the Earth's orbit around the Sun (approximated by a circle), a far-off star labeled Proxima Centauri, and an even more distant background of stars. (Note: Proxima Centauri is not in the same plane as the Earth's orbit, but the measurements used to determine parallax and distance will not be affected by this difference.)

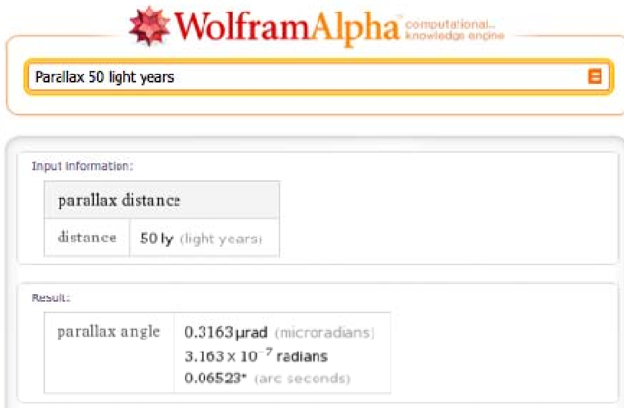
• Ask students to draw a line through Proxima Centauri and the Sun, and to draw a second line perpendicular to the first through the Sun. Now ask them to find the intersection of this second line with the orbit of the Earth, and draw lines connecting these two intersection points with Proxima Centauri. Point out that an isoceles triangle has now been created with two vertices on opposite sides of Earth's orbit and one vertex at Proxima Centauri. The smallest angle in this triangle represents the angular movement of the Earth against a background of very distant stars over the course of six months as seen by an observer at Proxima Centauri.

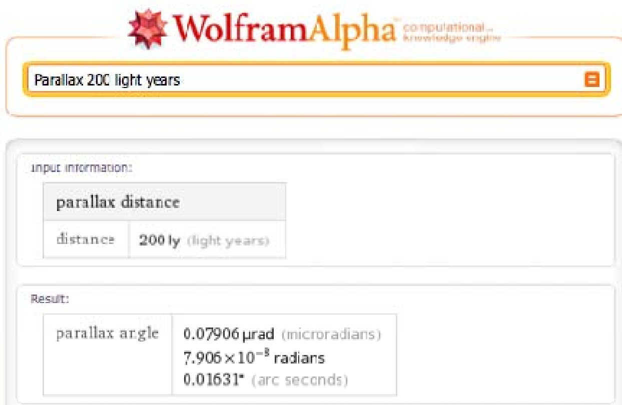
• Students should be able to find the measure of the small angle by using the law of cosines. Allow them to check their answer with W|A.



• Now ask students to draw two lines parallel to the Sun-Proxima line, one through each of the triangle vertices lying on the Earth's orbit. Using these lines as the lines of sight of an Earth-based observer, students should recognize that their sum is equal to the small angle within the triangle; in other words, Proxima has the same angular motion in Earth's sky that Earth has in Proxima's. This angular displacement, 1.546 arc seconds, corresponds to a distance of 266,757 astronomical units. Astronomers define parallax angle as one half of this angular displacement (in this case, 0.773 arc seconds).

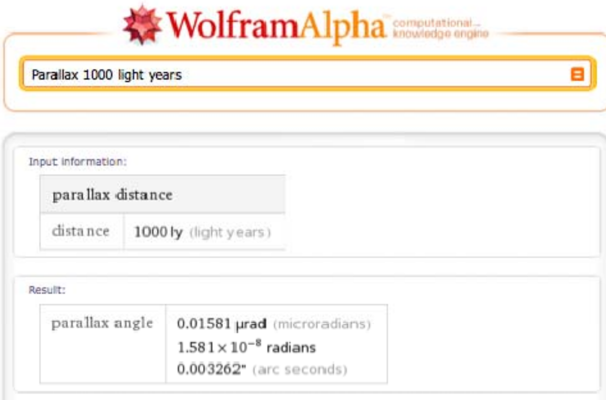
• Have students use W|A to compute parallax angles for the following distances (this time measured in light-years rather than astronomical units): 10 light-years, 50 light-years, 200 light-years.





Closing

• Explain that parallax is a useful method for determining distances to nearby stars, but it has limits. It can only be used to find distances to stars with parallaxes large enough to measure with precision. Explain to students that the angular resolution of a telescope (the limit of its precision) is directly proportional to the wavelength of light being observed and inversely proportional to the diameter of the telescope aperture. The largest optical telescopes in the world, observing at long blue-light wavelengths, might approach a resolution of 0.01 arc seconds. Now ask students to compute the parallax angle for a star 1000 light-years away. Can astronomers reliably measure the distance to this star using the parallax method?



Demonstrations

Parallax

Tracking and Separation (Visual Depth Perception 11)