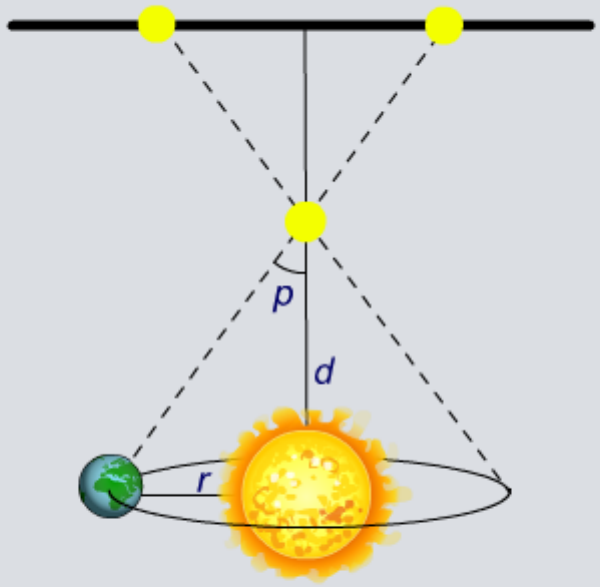
Astronomical Distances



The evolving Universe

Astronomical distances

Planets, stars and galaxies, and the distances between them, are huge when compared with everyday measurements:

- distance from Earth to Sun: 149,598,000,000 m
- distance from Sun to galactic center: 2.5 × 1020 m

To make these distances easier to use, physicists and astronomers use much larger, **non-SI units** to describe them:

1 **astronomical unit** (AU) = mean distance from Earth to Sun
= **1.5×10^{11} m**

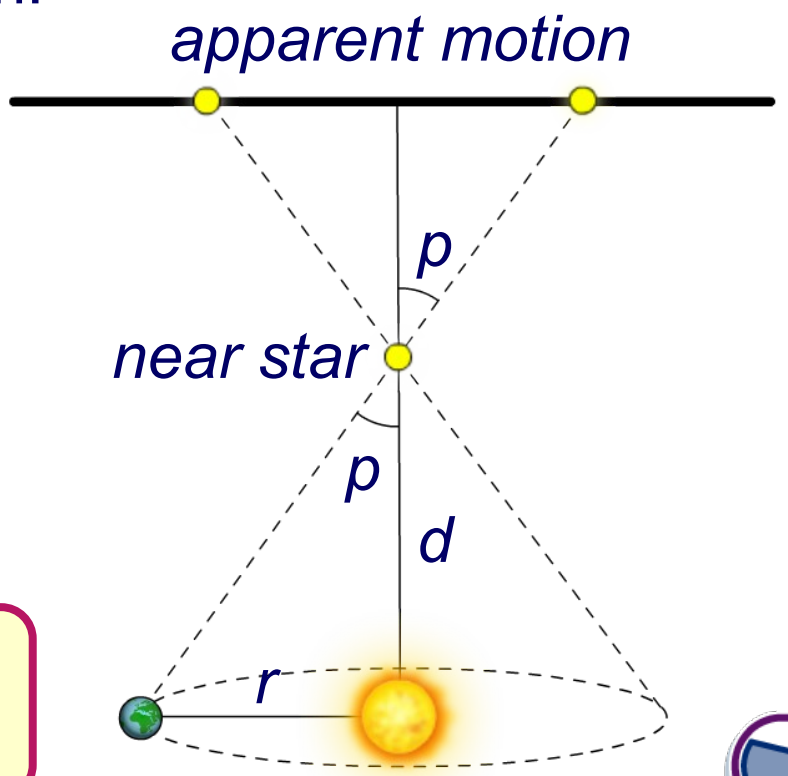
1 **light year** (ly) = distance light travels in a year
= **9.5×10^{15} m**

Parallax

Using parallax to measure distance

The closer a star is to the Earth, the more parallax it shows as the Earth orbits the Sun. How can parallax be used to measure this distance?

The parallax angle, *p*, is defined as half the angle that the near star appears to move through:



The distance from the Earth to the Sun, *r*, is 1 AU, so using trigonometry:

$$\tan p = \frac{r}{d}$$

But *p* is very small angle, so $\tan p \approx p$:

$$p = \frac{r}{d} \quad \text{so} \quad d = \frac{r}{p}$$

What is a parsec?

The word parsec is a shortening of ‘parallax of one arcsecond’. An **arcsecond** is a small division of a degree, which is a useful measurement in astronomy because the night sky is so vast. An arcminute is a 60^{th} of a degree, and an arcsecond is a 60^{th} of an arcminute, or one 3600^{th} of a degree.

A parsec is the distance away an object must be to have a parallax of one arcsecond when observed from Earth.

1 parsec (pc) = 1 astronomical unit / 1 arcsecond

[1 AU = 1.5×10^{11} m] [1 arcsecond = $2\pi/(360 \times 3600)$ rad]

$1\,pc = 3.1 \times 10^{16}\,m$

How does this compare to a lightyear? **$1\,pc = 3.3\,ly$**

…and an astronomical unit? **$1\,pc = 2.1 \times 10^{5}\,AU$**

Converting units