SECRETS OF THE SOLAR SYSTEM

S^3-03

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American Museum of Natural History

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Brain Teaser

If the Sun is
93,000,000 miles away from Earth,

and you are driving at **100 miles/hour**

How many hours would take you to get there?
(days/years?)

Outline

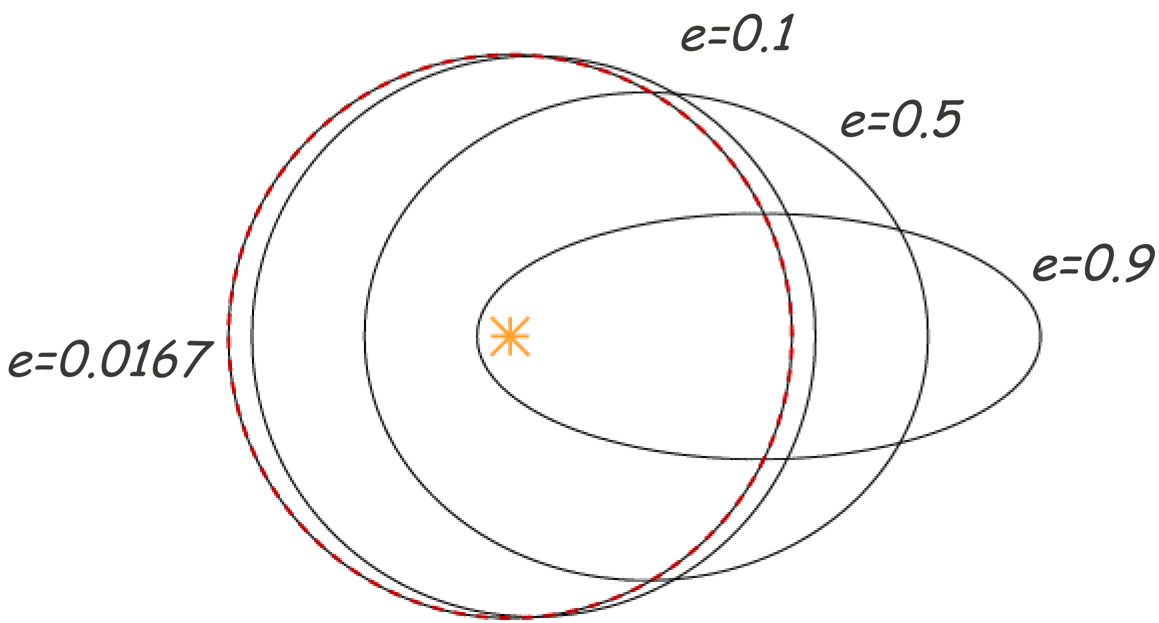
Seasons

Scales of the Solar System

Orbits

Seasons

Seasons on Earth are **NOT** because of eccentricity

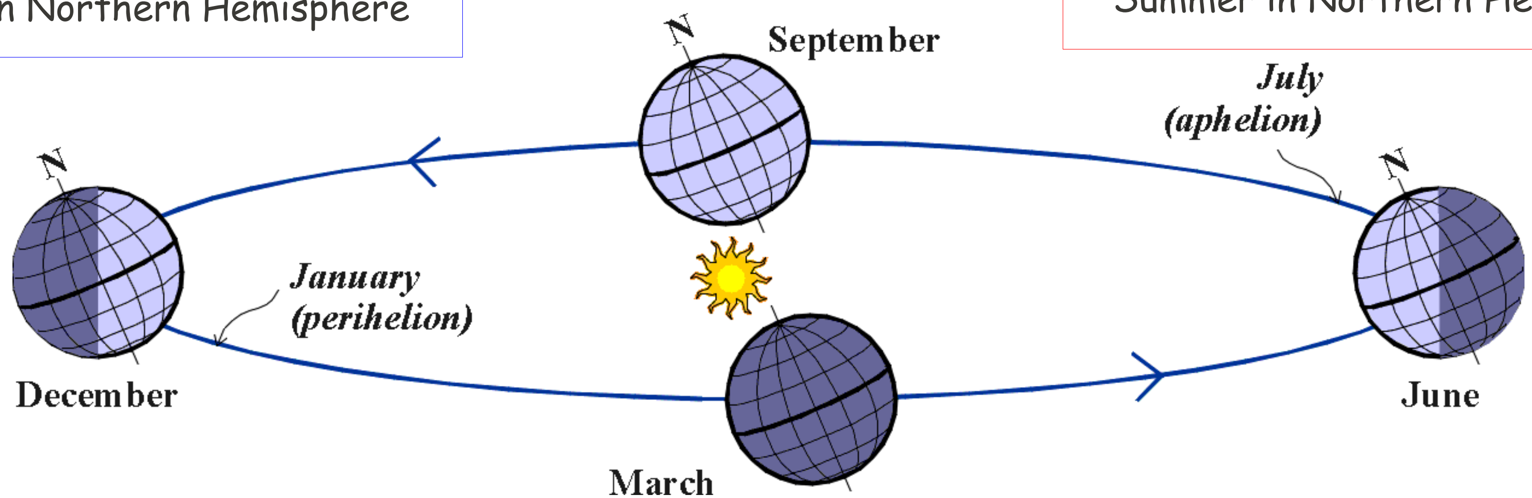


Earth's eccentricity of 0.0167 makes its orbit pretty much a circle

Seasons

December solstice
Summer in Southern Hemisphere
Winter in Northern Hemisphere

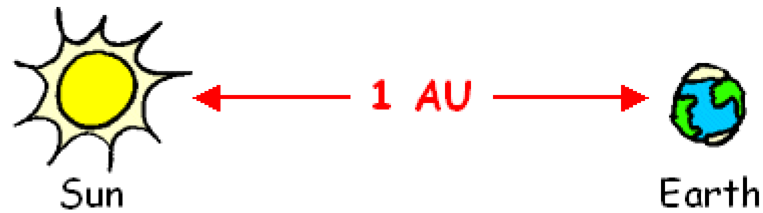
June solstice
Winter in Southern Hemisphere
Summer in Northern Hemisphere



Earth's tilt defines the seasons

A very eccentric planet would have
"eccentricity seasons" in addition to **"tilt seasons"**,
but NOT Earth, whose orbit is very close to CIRCULAR!

Distances in the Solar System



Astronomical Unit

The mean Earth-Sun distance

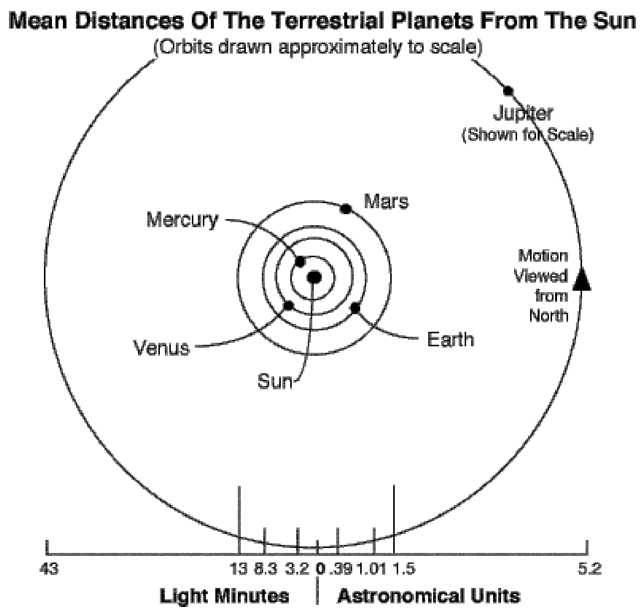
Less used units:

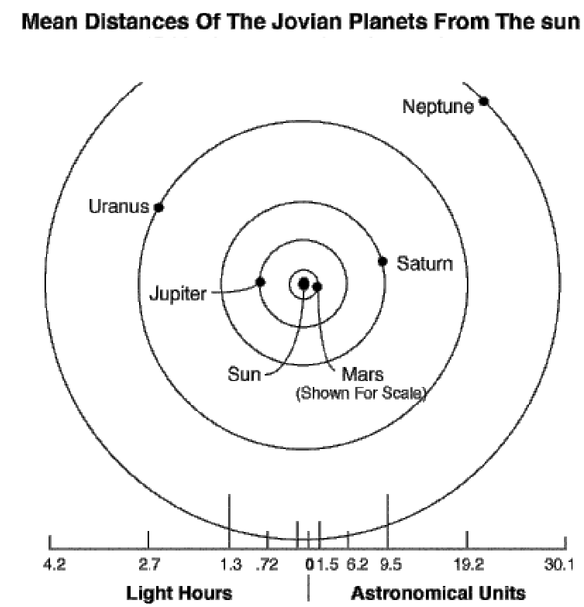
Light-second:
Mean Earth-Moon distance is 1.282 light-seconds

Light-minute:
1 AU is 8.317 light-minutes

Light-hour:
Pluto's semi-major axis is 5.473 light-hours

Distances in the Solar System





Inner Solar System	
Mercury	0.39 AU
Venus	0.72 AU
Earth	1.00 AU
Mars	1.52 AU

Outer Solar System	
Jupiter	5.2 AU
Saturn	9.5 AU
Uranus	19.2 AU
Neptune	30.1 AU

How do we know the distances in AU?

Planet	Distance (AU)
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
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Kepler's 3rd Law!

$$T^2 = k r^3$$

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$$T_{Earth}^2 = k r_{Earth}^3$$

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$$T^2 = k\,r^3$$

$$T_{Earth}^2 = k\,r_{Earth}^3$$

$$\left(\frac{T}{T_{Earth}}\right)^2 = \left(\frac{r}{r_{Earth}}\right)^3$$

Kepler's 3rd Law!

$$T^2 = k\,r^3$$

$$T_{Earth}^2 = k\,r_{Earth}^3$$

$$\left(\frac{T}{T_{Earth}}\right)^2 = \left(\frac{r}{r_{Earth}}\right)^3$$

$$\left(\frac{T}{1\,yr}\right)^2 = \left(\frac{r}{1\,AU}\right)^3$$

Kepler's 3rd Law!

$$T^2 = k\,r^3$$

$$T^2_{Earth} = k\,r^3_{Earth}$$

$$\left(\frac{T}{T_{Earth}}\right)^2 = \left(\frac{r}{r_{Earth}}\right)^3$$

$$\left(\frac{T}{1\,yr}\right)^2 = \left(\frac{r}{1\,AU}\right)^3$$

$$\boxed{T^2_{yr} = r^3_{AU}}$$

Measure the period (in yr), get the distances (in AU)!

Planet	Orbital Period (yr)	Distance (AU)
Mercury	0.241	0.39
Venus	0.615	0.72
Earth	1.000	1.00
Mars	1.881	1.52
Jupiter	11.68	5.2
Saturn	29.46	9.5
Uranus	84.32	19.2
Neptune	164.8	30.1

$$T_{yr}^2 = r_{AU}^3$$

Hall Tour

Activity

Measure the period (in yr), get the distances (in AU)!

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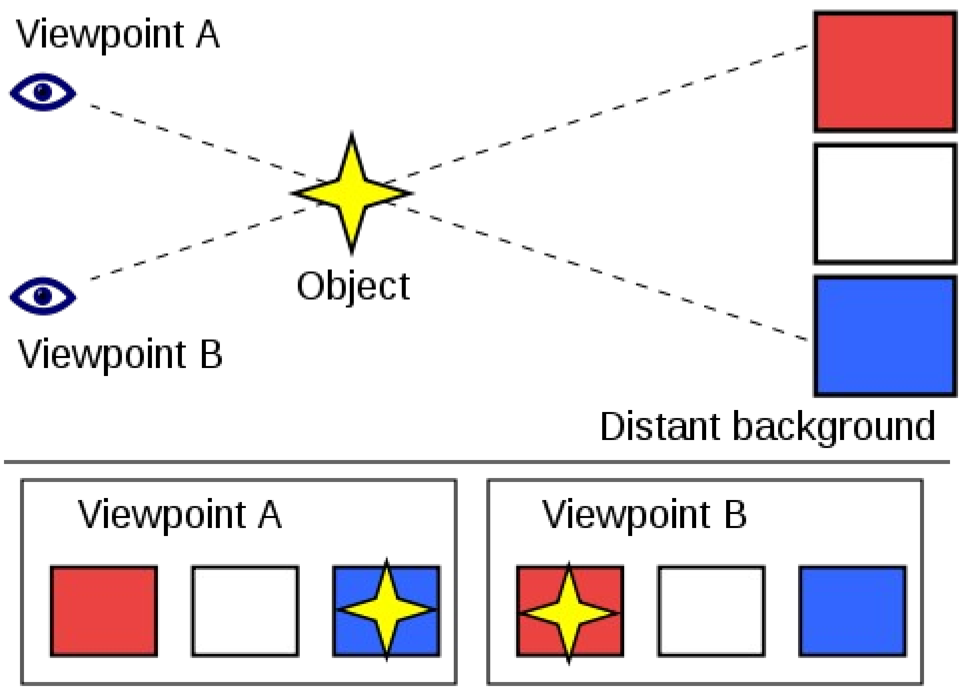
$$T^2_{yr} = r^3_{AU}$$

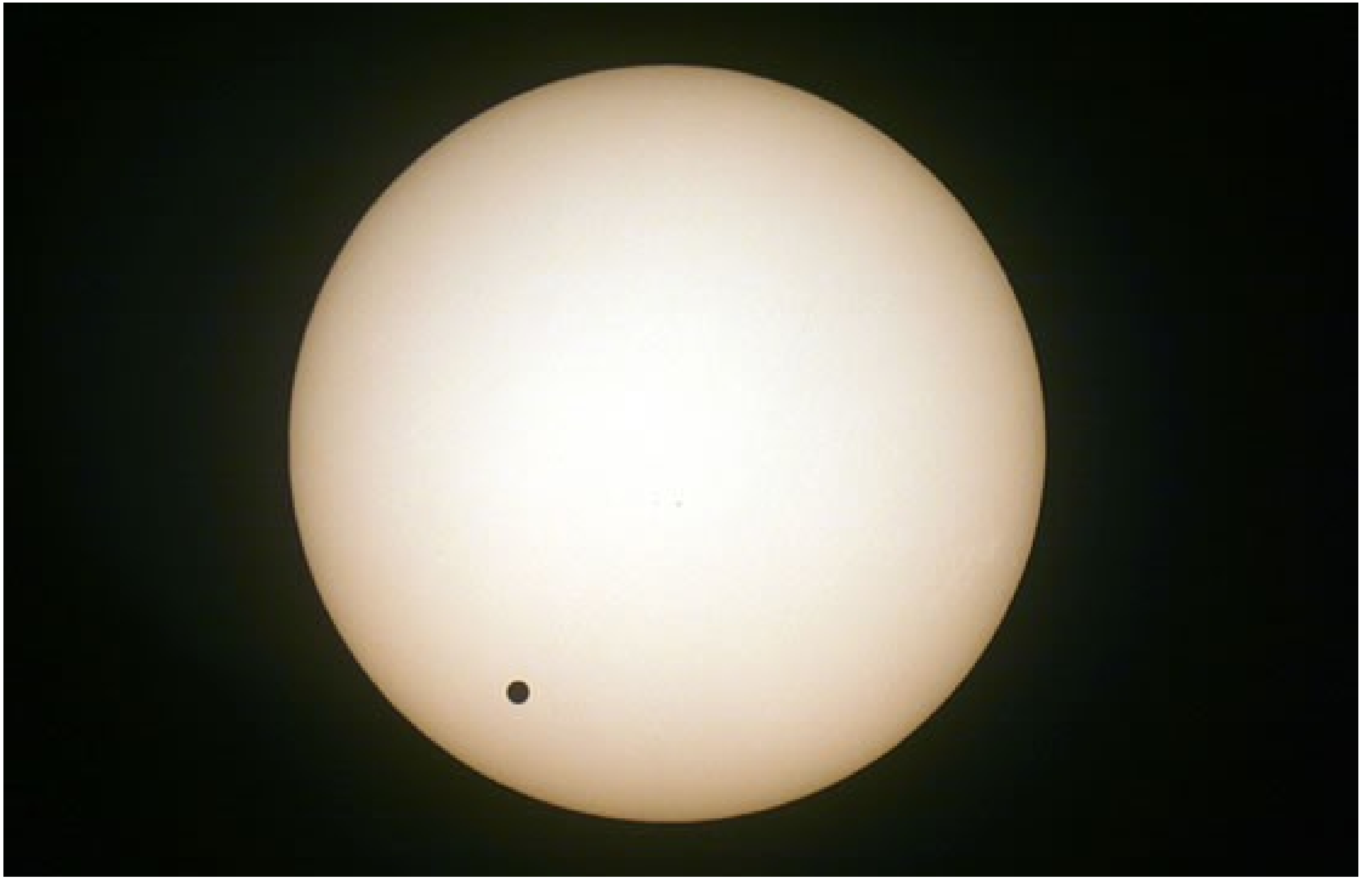
But how do we quantify 1 AU?

Measure the distance to one of the planets

Via parallax



Transit of Venus



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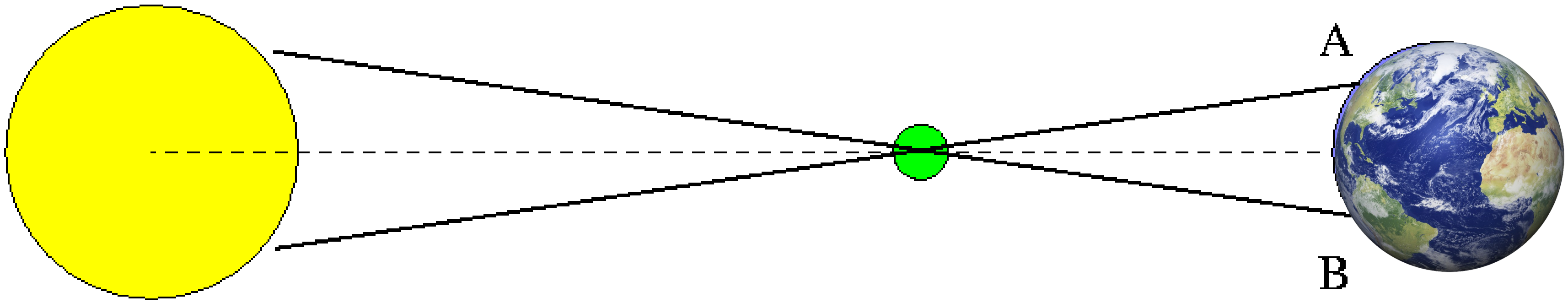
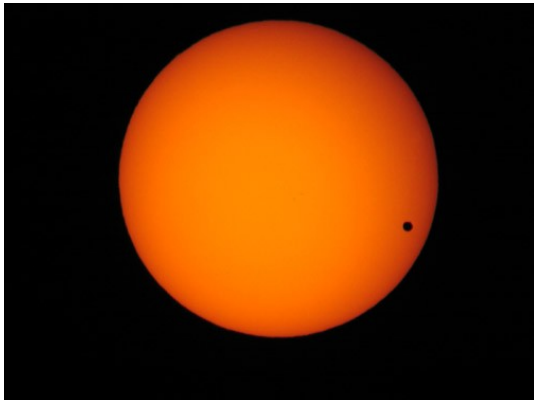
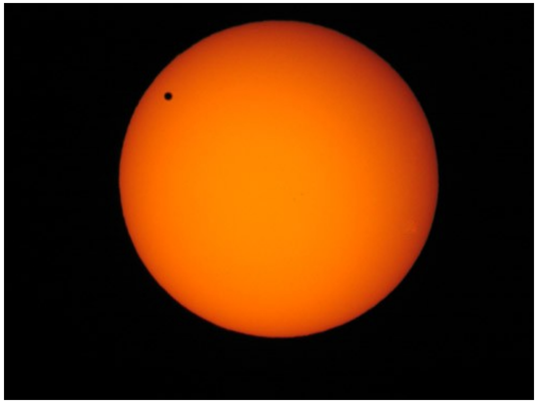
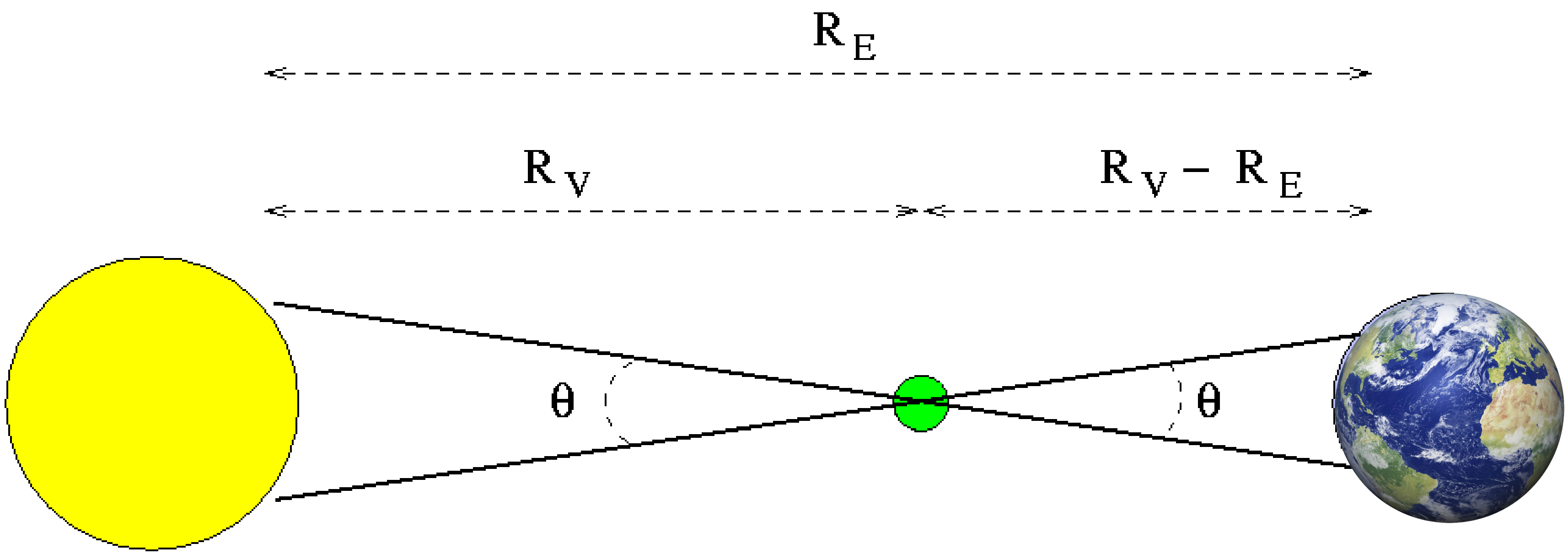


View from A



View from B





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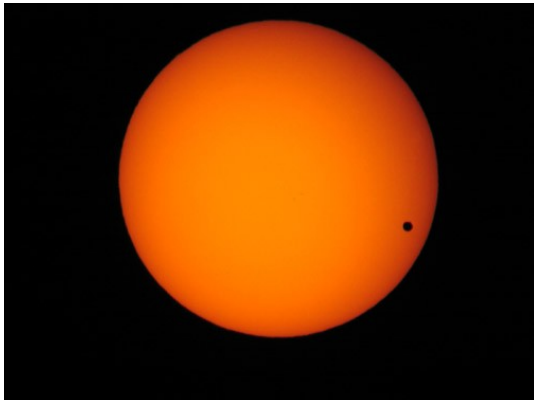
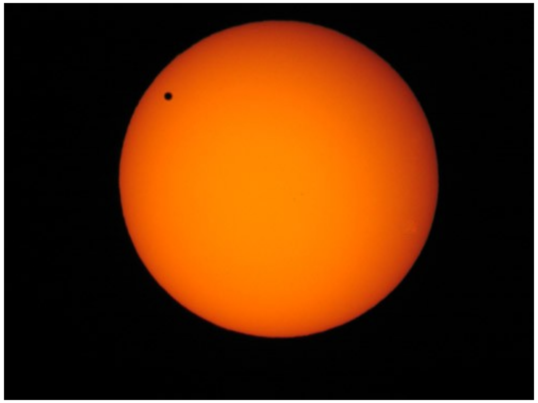


View from B



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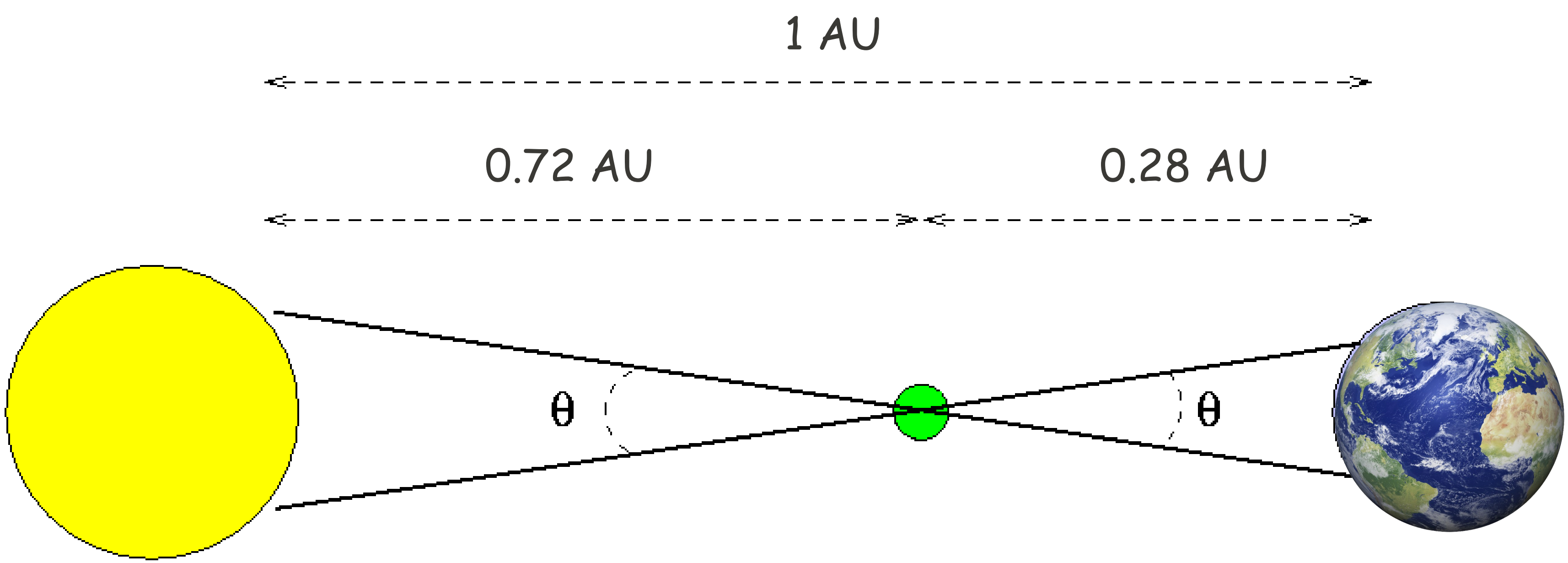
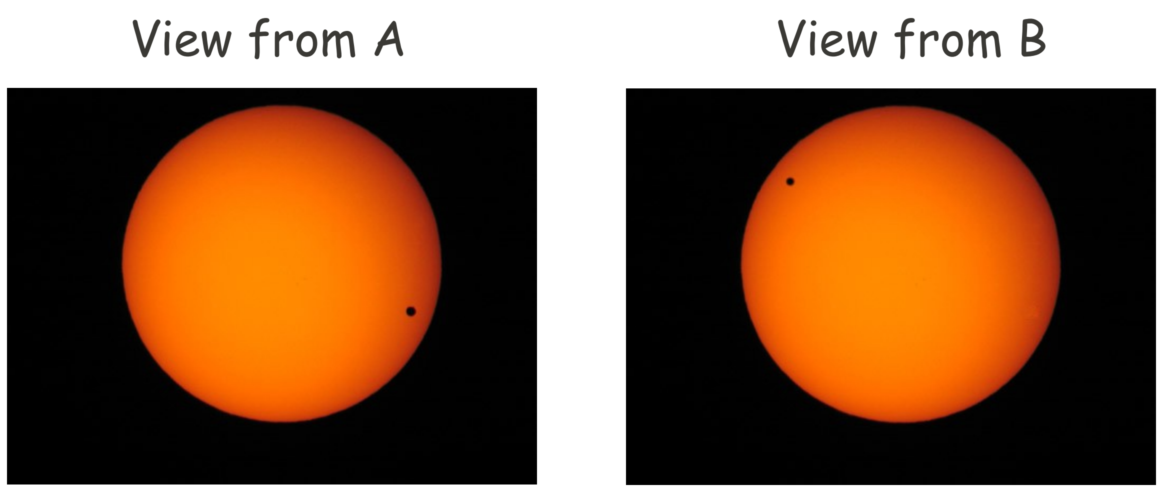
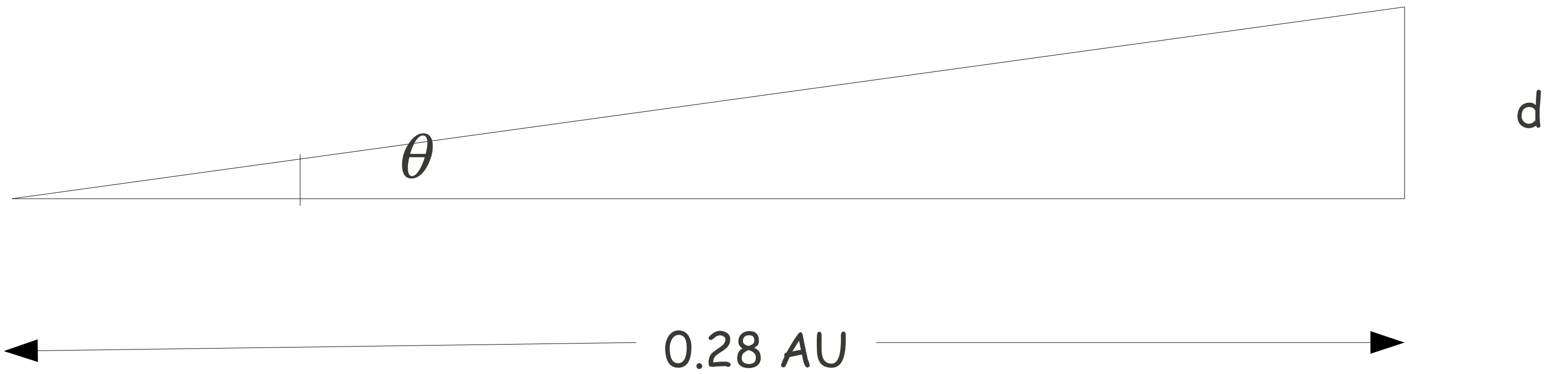
$$T_{yr}^2 = r_{AU}^3$$


1 AU
0.72 AU
0.28 AU
θ
θ


View from A
View from B

Basic Trigonometry!



$$1 \text{ AU} = 1.49 \times 10^8 \text{ km}$$

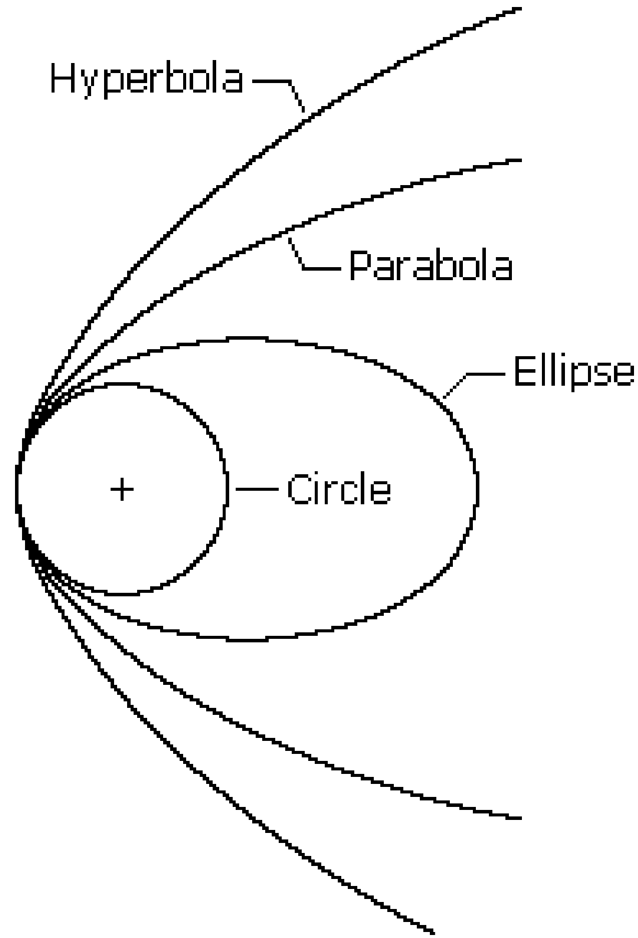
Why are orbits elliptic?

Types of orbit

Orbit Type	Eccentricity	Energy
Circle	$e = 0$	$E = E_{min}$
Ellipse	$0 < e < 1$	$E_{min} < E < 0$
Parabola	$e=1$	$E = 0$
Hyperbola	$e > 1$	$E > 0$

Bound

Unbound



Types of orbit: Conic Sections