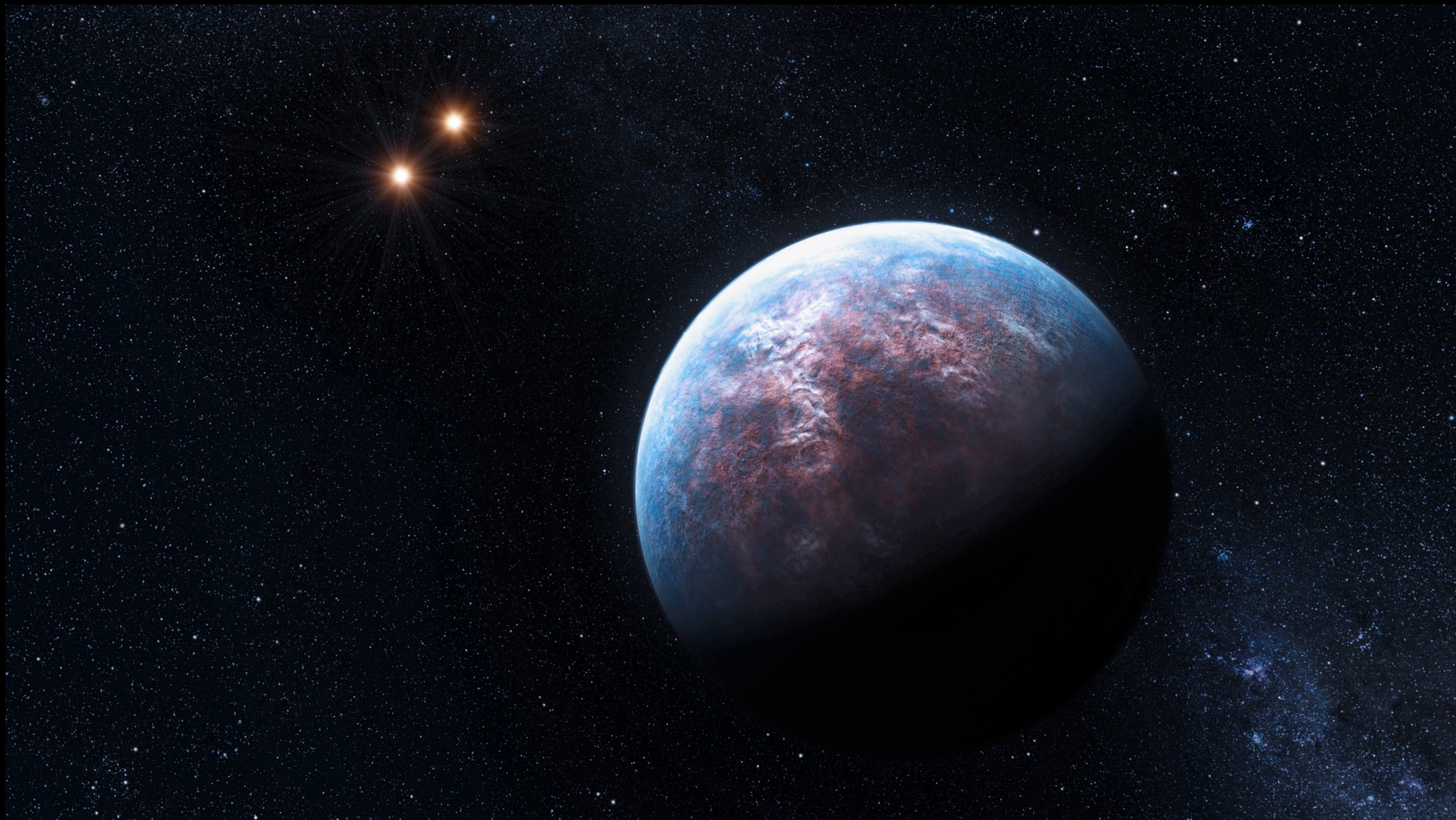
The Hunt for New Worlds



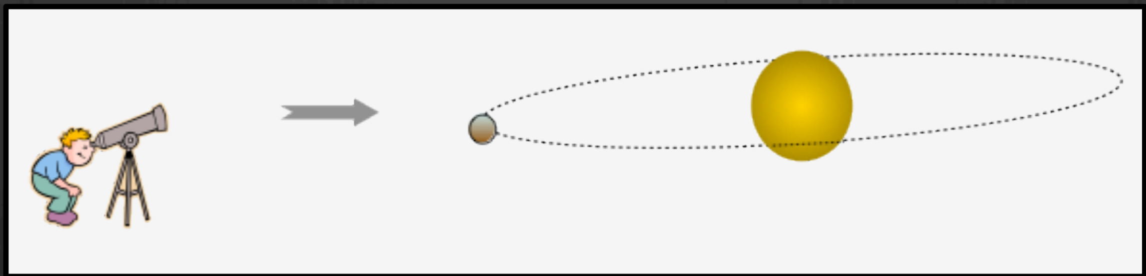
Transits

Transit of Venus
June 2012

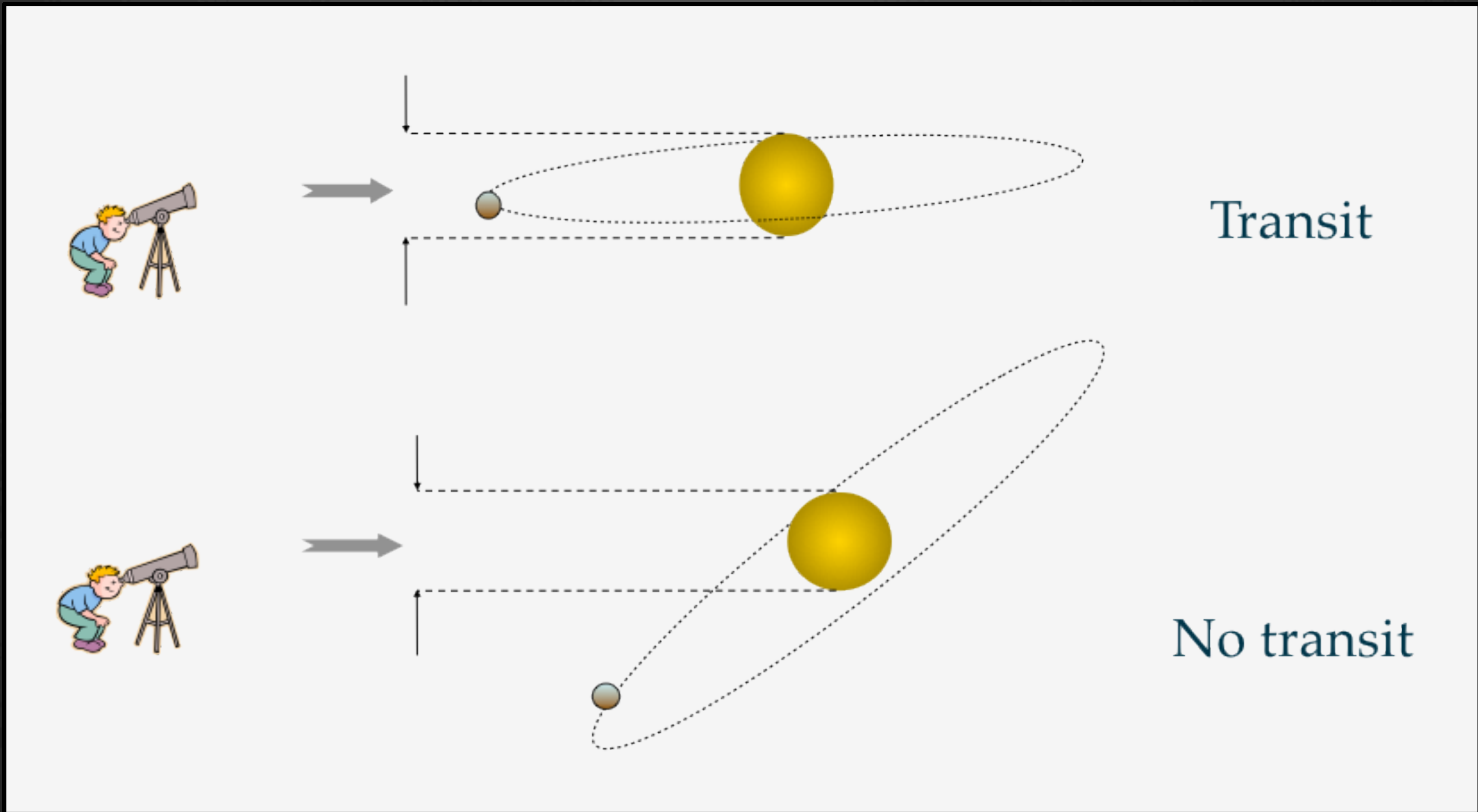
Next transit
expected
December 2117

Transiting Exoplanet

- Planet passes through the line of sight from Earth to the Exoplanet's host star, blocking part of the star's light from our perspective
- Using photometry, we can measure the slight change in the star's brightness

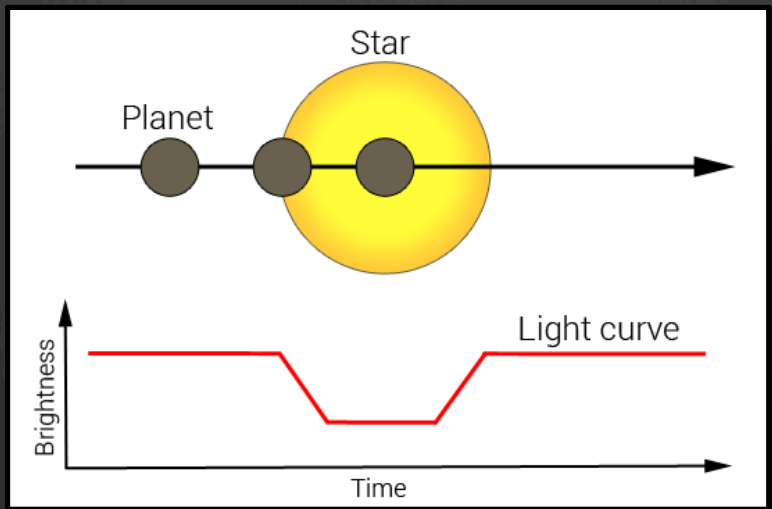


Transit Geometry



Transit Light Curve

- The slight change in the star's brightness is observed as a transit light curve
- The transit light curve is encoded with lots of data about the exoplanet and its host star



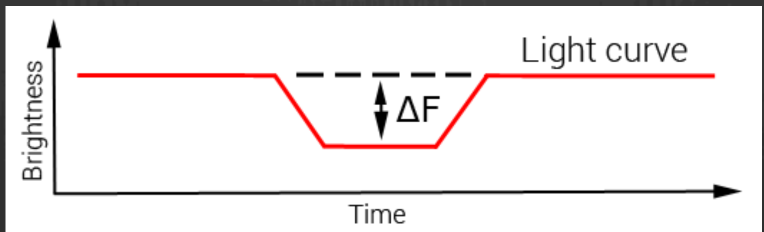
Radius of Exoplanet

- The radius of the exoplanet is related to the slight change in the star's brightness observed

Dip in star's brightness → $$\Delta F = \frac{R_p^2}{R_*^2}$$

Radius of exoplanet → R_p^2

Radius of host star → R_*^2

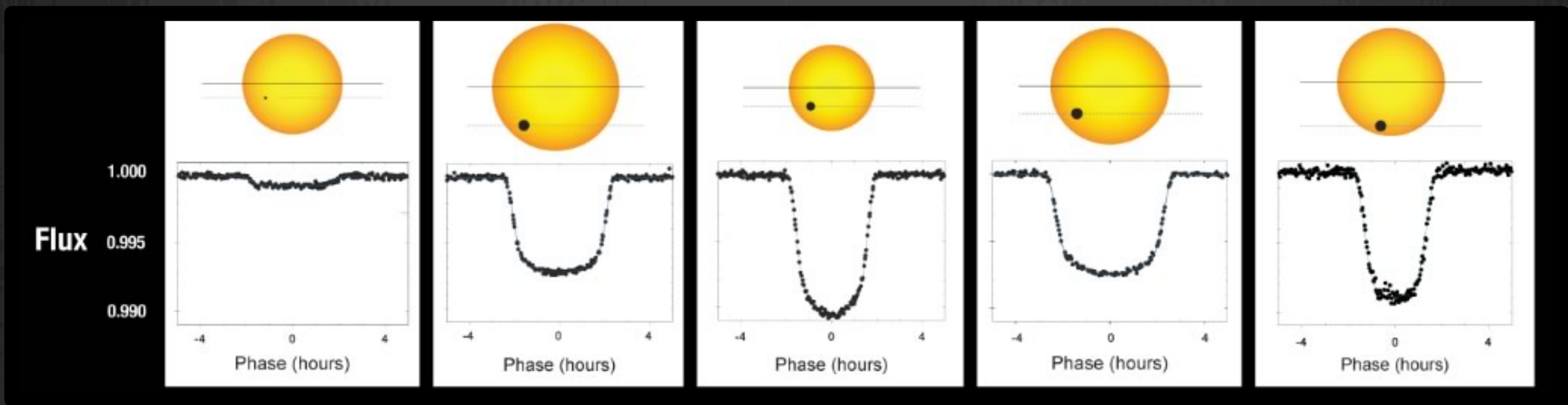


Radius of Exoplanet

Dip in star's brightness → $$\Delta F = \frac{R_p^2}{R_*^2}$$

Radius of exoplanet (R_p)

Radius of host star (R_*)



Orbital Period

- The period can be measured from observations using the relationship:

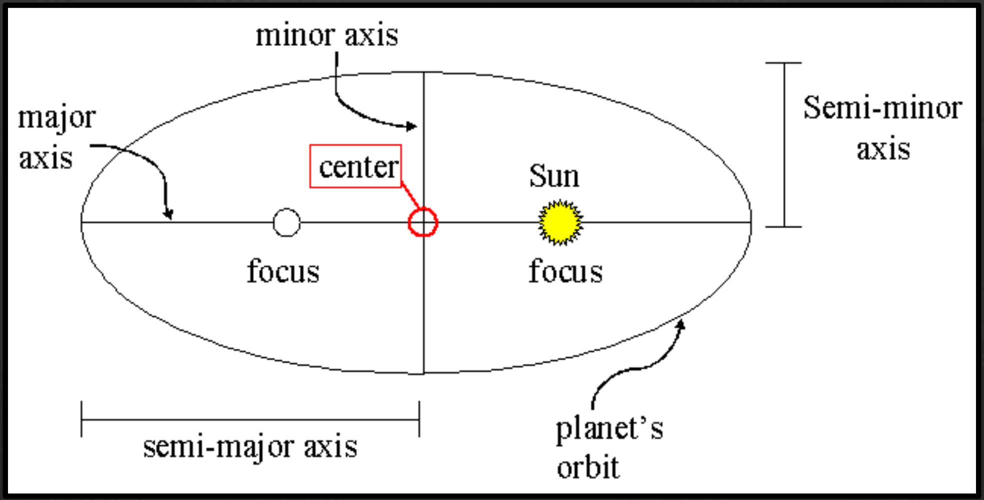
Orbital Period → $$P = \frac{T_{elapsed}}{N_{cycles}}$$

- Where $T_{elapsed}$ is the elapsed time between two observed occurrences of the same even, i.e. the mid-transit times

- And N_{cycles} is the number of cycles between the two occurrences

Orbital Semi-Major Axis

- Semi-major axis is a term that astronomers use to mean "radius of orbit."
- Using "radius of orbit" or "orbital radius" isn't entirely precise, because nearly every body in space orbits on an ellipse
- Its value is important as it tells us how close and how far an exoplanet gets from its host star



Orbital Semi-Major Axis

- Kepler's Third Law of Planetary Motion allows us to calculate the orbital semi-major axis

Mass of the star

Orbital period
We just calculated that!

Semi-major axis

$$a^3 \approx \left(GM_* \left(\frac{P}{2\pi} \right)^2 \right)^{1/3}$$

A well known constant

…but how do we get the mass of the star?

Classifying Stars

- Different stars can be categorised into certain groups, depending on their mass and temperature
- We find that stars of different temperatures appear to shine with different colours
- The different colour stars tend to have similar mass

Class	Temperature (°C)	Colour
O	> 30,000	Blue
B	20,000	Blue-White
A	10,000	White
F	7,000	Yellow-White
G	6,000	Yellow
K	5,000	Orange
M	3,000	Red

What Else Can The Light Curve Tell Us?

The transit light curve also allows us to work out the planet's

- Orbital eccentricity
- Orbital inclination
- Mass
- Atmosphere composition
- Exomoons!

How Do We Get Light Curves?

Ground-based Telescopes

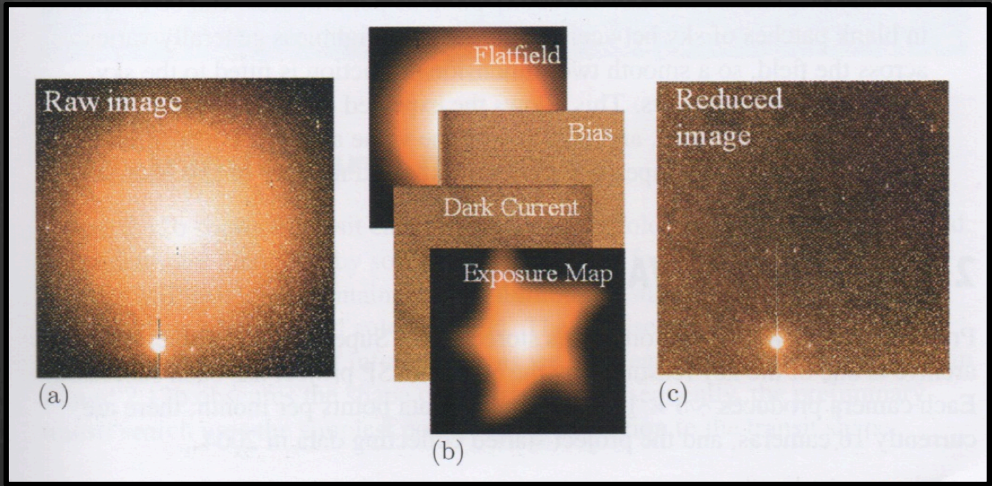
Space-based Telescopes

Kepler Telescope

42 camera sensors!

From Images to Light Curves

- The raw data from the cameras need to be corrected to remove distortion



- The first image shows the raw photo, the middle shows the corrections applied, and the final "reduced" image is the one we work with!

Now It's Your Turn!

- Analyse reduced images from ground-based and space-based telescopes
- Plot a light curve of the exoplanet transit
- Characterise the exoplanet using data from your light curve
- Determine if your planet is habitable for life!