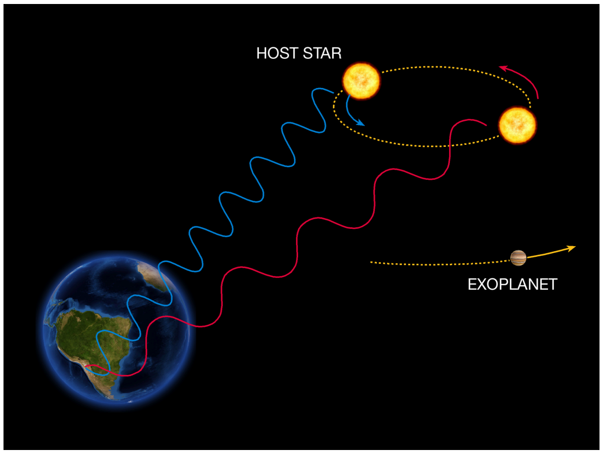
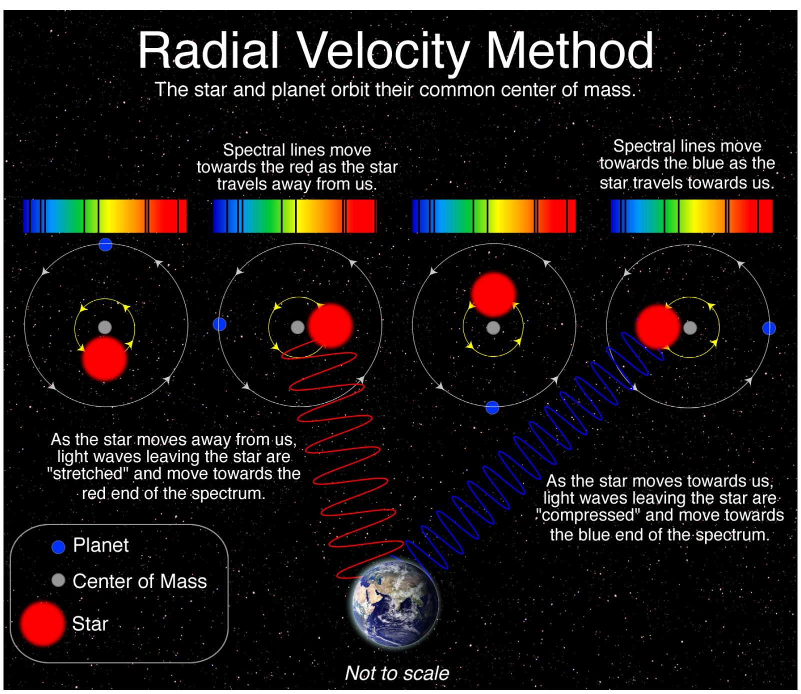
EXOPLANET DETECTION METHODS

5 WAYS TO FIND AN EXOPLANET/PLANET

1.Radial Velocity (Doppler) Method



How it works:
:The planet's gravity causes the star to "wobble" slightly. This wobble shifts the star's light spectrum (redshift/blueshift).



What is measured:

- Changes in the star's velocity along the line of sight

Key Equation:

- Radial velocity amplitude:

$$K = \left(\frac{2\pi G}{P}\right)^{1/3} \frac{M_p \sin i}{(M_* + M_p)^{2/3}} \cdot \frac{1}{\sqrt{1 - e^2}}$$

Where:

- K: radial velocity amplitude
- G: gravitational constant
- P: orbital period
- Mp: mass of planet
- M*: mass of star
- i: inclination angle
- e: eccentricity of orbit

2.Transit Method

How it works:
A planet passes in front of its star (from our viewpoint), causing a small dip in the star's brightness.

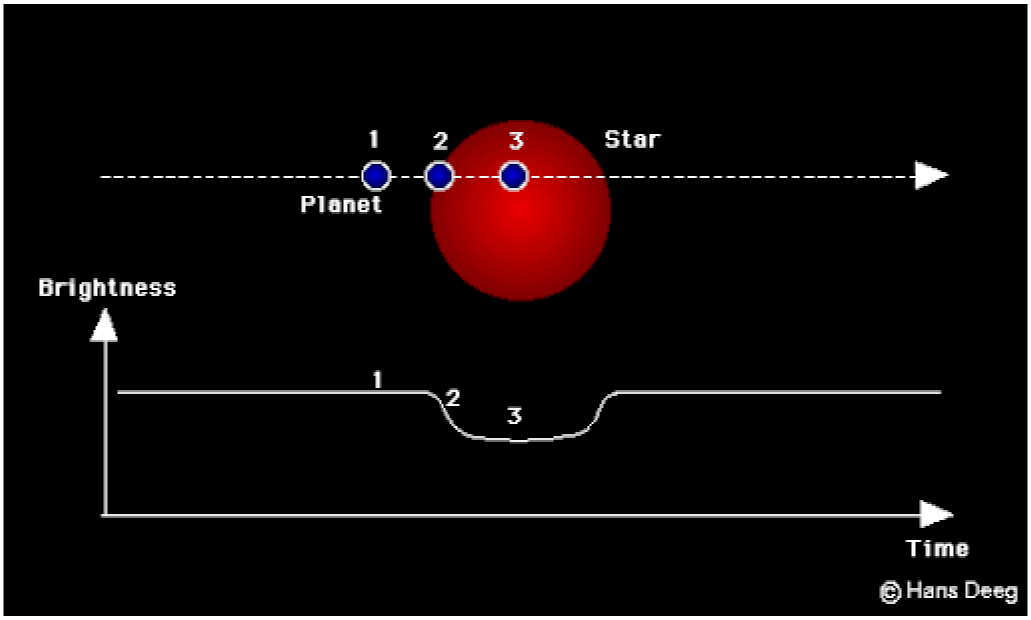


Diagram:
→ Star dims → Planet blocks some light

What is measured:

- Dip in brightness
- Time between dips (orbital period)

Key Equation:

- Transit depth (how much light is blocked):

$$\frac{\Delta F}{F} = \left(\frac{R_p}{R_*}\right)^2$$

Where:

- ΔF: decrease in flux (brightness)
- F: total flux
- Rp: radius of planet

- R*: radius of star

Orbital distance (Kepler's Third Law):

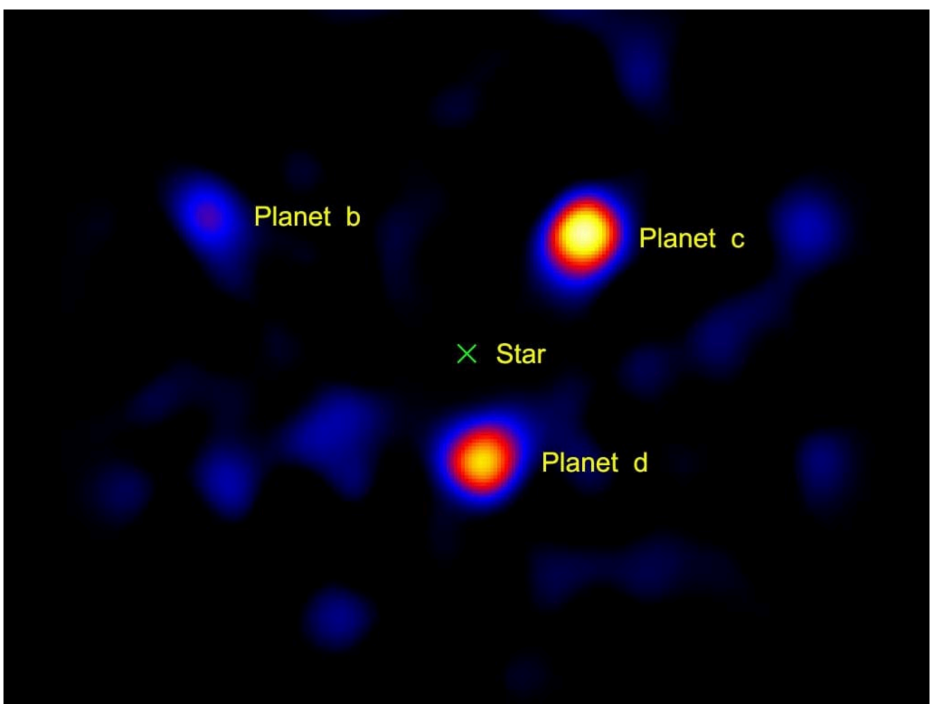
$$a^3 = \frac{GM_* P^2}{4\pi^2}$$

Where:

- a: semi-major axis (average distance between star and planet)
- G: gravitational constant
- M*: mass of the star
- P: orbital period (time between transits)

3.Direct Imaging

How it works:
Take a photo of the exoplanet by blocking out the star's light using a coronagraph or starshade.

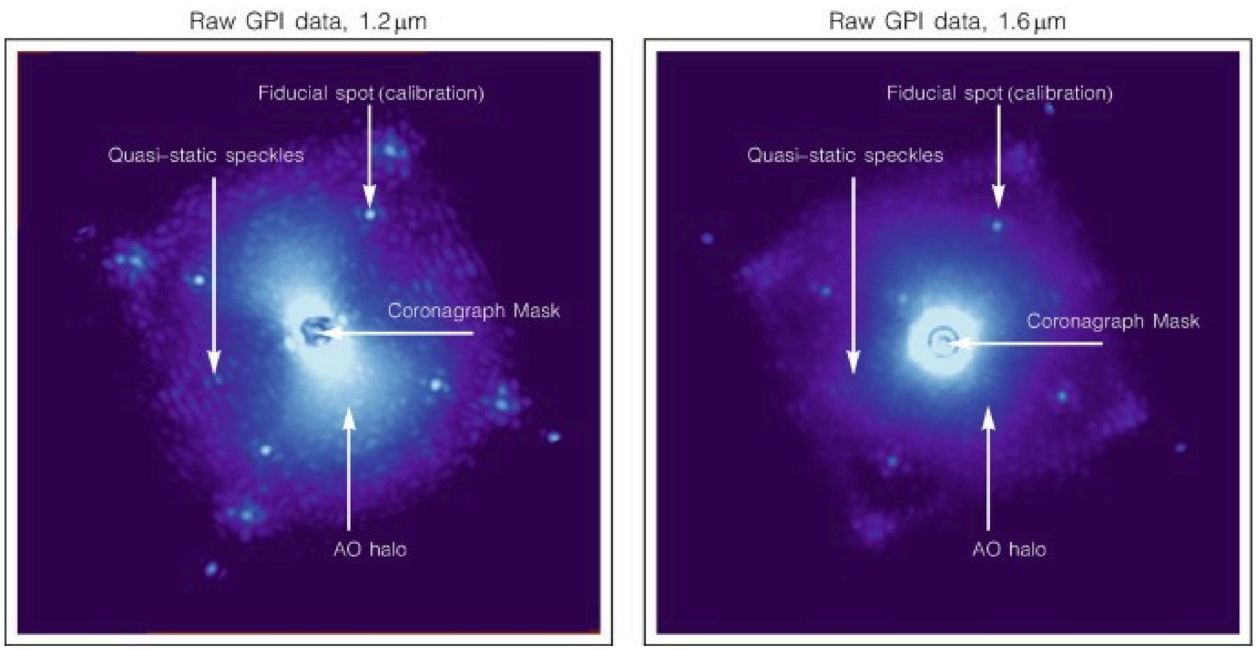


What is measured:

- Light from the planet (reflected or emitted)

Equation (for brightness):

$$L_p = A \cdot \left(\frac{R_p^2}{a^2} \right) \cdot L_*$$

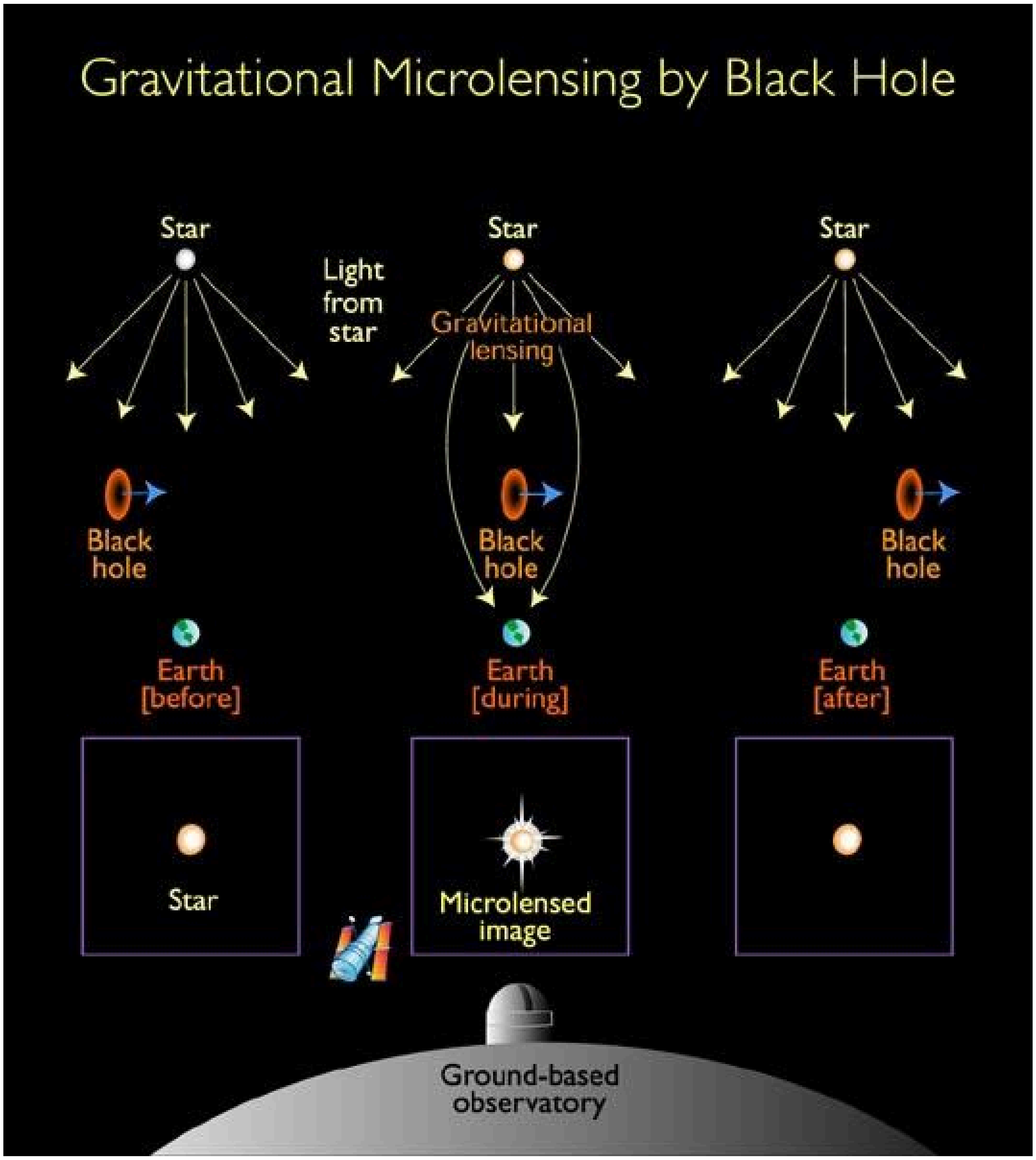


Where:

- Lp: planet's luminosity
- A: albedo (reflectivity)
- Rp: radius of planet
- a: distance from the star
- L∗: star's luminosity

4. Gravitational Microlensing

How it works:
A foreground star (with a planet) passes in front of a background star. The gravity of the foreground system bends the light, acting like a magnifying glass.



What is measured:

- Temporary brightening of the background star

Key Equation:

- Einstein Radius:

$$\theta_E = \sqrt{\frac{4GM}{c^2} \cdot \left(\frac{D_{LS}}{D_L D_S}\right)}$$

Where:

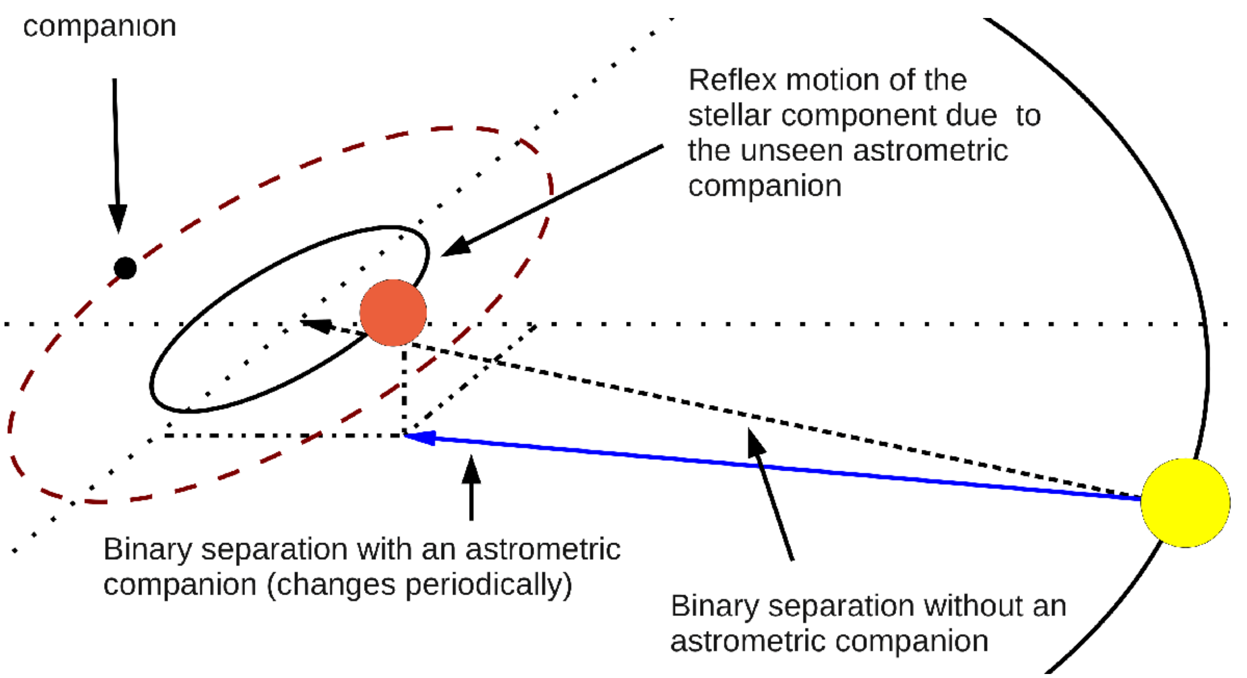
- θE: angular Einstein radius
- G: gravitational constant
- M: lensing mass
- c: speed of light
- DL,DS: distances to lens and source stars
- DLS=DS−DL

5. Astrometry

How it works:
Measures tiny changes in a star's position in the sky caused by an orbiting planet.

What is measured:

- Star's positional shifts



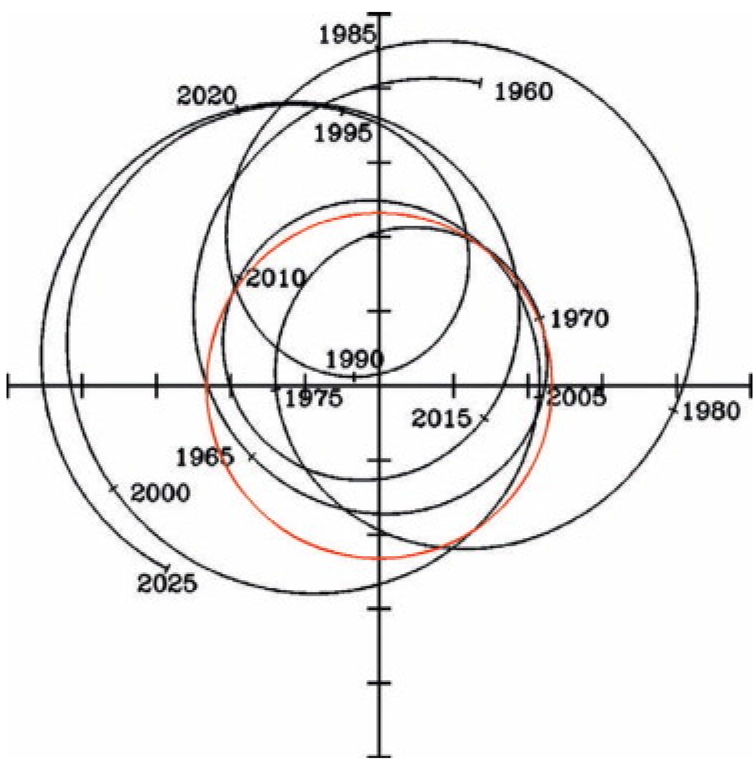
Key Equation:

- Angular displacement:

$$\alpha = \left(\frac{M_p}{M_*}\right) \cdot \left(\frac{a}{d}\right)$$

Where:

- alpha(α): angular shift in arcseconds
- Mp: mass of planet
- M∗: mass of star
- a: orbital distance
- d: distance to the system from Earth



REFERENCES:

1. Google picture