



EXOPLANET DISCOVERY

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WHAT IS AN EXOPLANET?

- An exoplanet is a planet outside of our solar system
 - Extrastellar
 - Rogue
- 1853 Planets
 - 1162 planetary systems
 - 473 Multiple planetary systems



HISTORY OF EXOPLANET DISCOVERY

- Ancient Greeks speculated of other solar systems
- 1584 Giordano Bruno “countless suns and countless earths all rotating around their suns”
- In the 1960s Peter van de Kamp thought he discovered planets orbiting Barnard’s Star
 - Photographic plates
 - Gas giants
- Alexander Wolszczan in 1994
 - Pulsar
- 1995 first planet in orbit of a sun like star (51 Pegasi)
 - Radial Velocity



DIRECT EXOPLANET DISCOVERY METHOD

- Direct Observation
 - Nearly impossible to resolve reflected starlight
 - Viewed by observing thermal radiation of planet
 - Planets must be hot
 - Accurate with radius, not mass
 - First direct observation in 2004
 - 2M1207 and 2M1207B
 - “Very Large Telescope”
 - 100 Times more faint





VERY LARGE TELESCOPE

- Located in the desert of northern Chile
- Operated by European Southern Observatory
- Four individual Telescopes 8.2 meters across
- Visible to infrared wavelength
- Can detect objects four billion times more faint than the human eye can detect





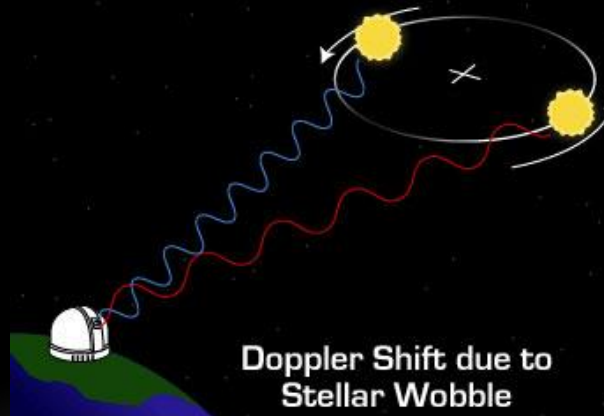
INDIRECT METHOD OF EXOPLANET DISCOVERY

- Changes in radial velocity
 - Doppler shifts indicate movement
 - This movement is caused by the gravitational pull of another planet
- Transit method
 - Planet travels between star and observer
 - Change in the amount of light received
- Orbital Brightness Modulus
 - Similar to transit method
 - More than just blocking star light
- Microlensing
 - Cool!
 - Uses relativity!



RADIAL VELOCITY METHOD

- A solar system is revolves around its center of mass
 - Newton's third law
 - Newton's law of gravitation
 - This will cause the star to move
 - Studying the Doppler shift can detect this movement





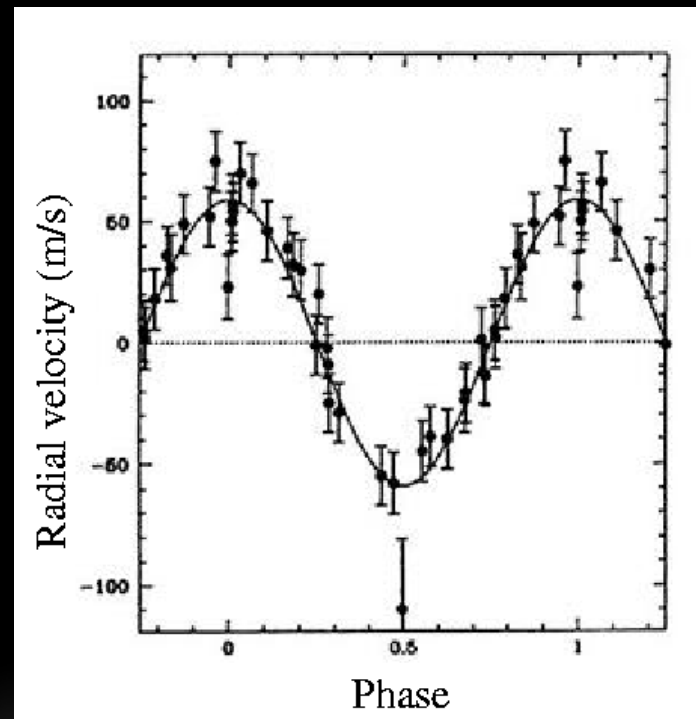
RADIAL VELOCITY METHOD CONTINUED

- Instrumental improvements have lead to the more planets being discovered by this method.
 - Improved CCDs
 - Radial velocity measurement precision has improved from 50 m/s to 1 m/s
- Accurate readings on mass
- Cannot give measurements for radius
- The closer the mass of the planet to the star, the easier to detect.
 - $r_1 = u/m_1$



RADIAL VELOCITY METHOD

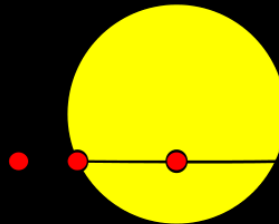
- <http://astro.unl.edu/naap/esp/detection.html>





TRANSIT METHOD

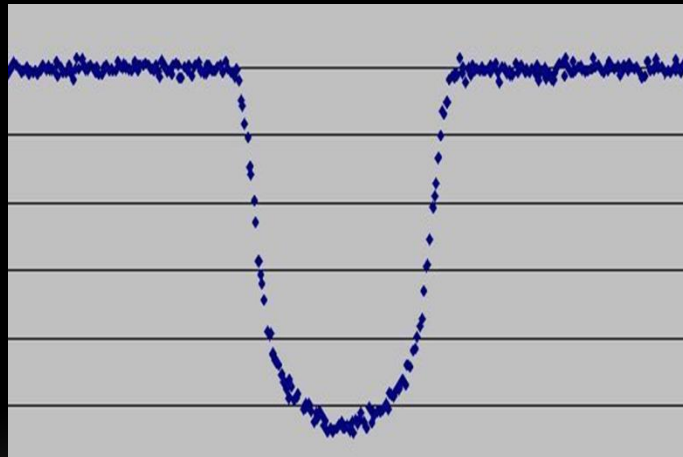
- Think of it as a very partial eclipse
 - Impossible to notice by just looking in a telescope
 - Photometry
- Measurement of the number of photons that reach the detector
- Accurate measurement of radius





TRANSIT METHOD CONTINUED

- Major drawbacks
 - Estimated that only 0.47% of planets that are 1 AU from sun will have transit that would be detectable from Earth
 - Up to 40% false positives.
 - Need other methods to confirm





TRANSIT METHOD MISSIONS

- Kepler Spacecraft
 - Launched in 2009
 - Confirmed 995 exoplanets, 3000+ candidates
- COROT
 - CONvection ROTation and planetary Transits
 - French space agency
 - >30 observations
 - Failed



ORBITAL BRIGHTNESS MODULATIONS

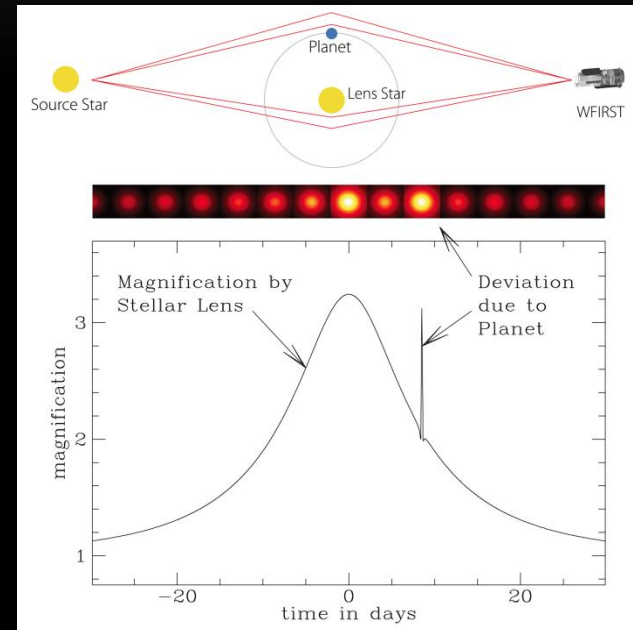
- Hard to resolve
- Star shines on the planet
 - Additional brightness
 - Additional warmth





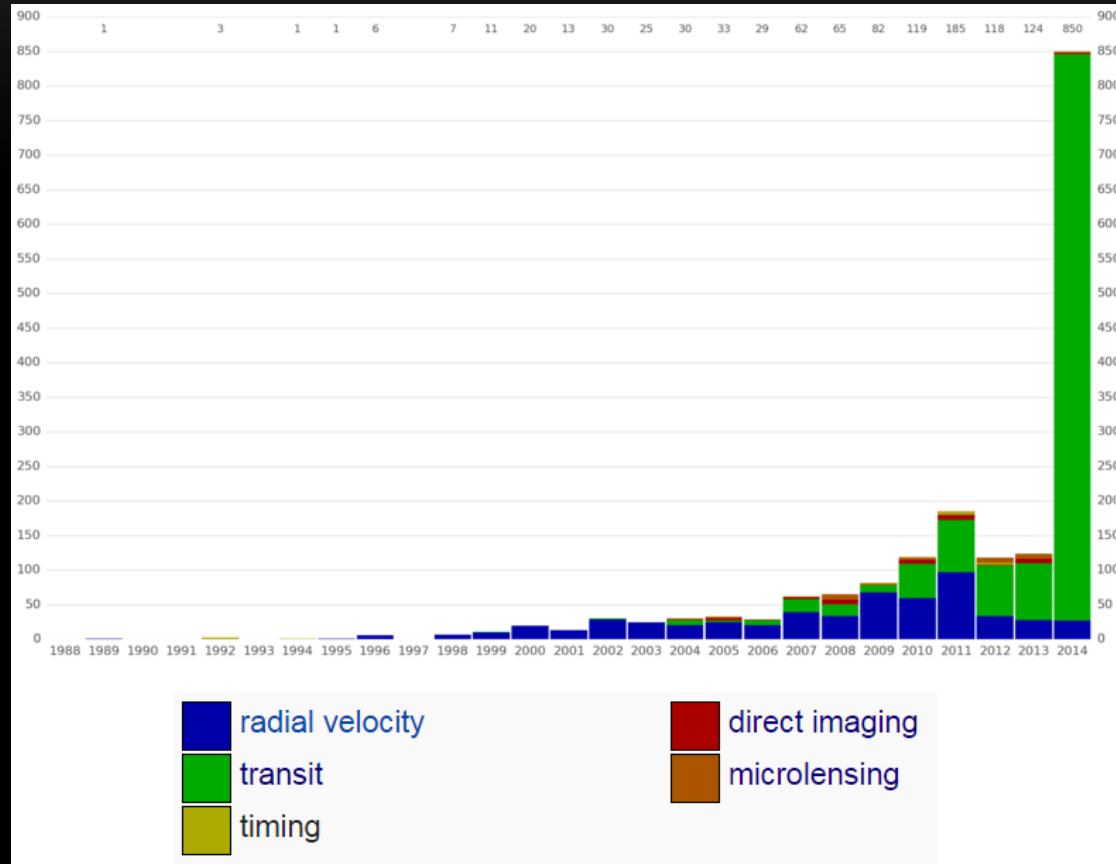
MICROLENSING

- Distant star light bend applied to planets
- Planet works as lens bending light
- Planet doesn't need to emit any radiation
 - Can be very cold
- 19 exoplanets have been detected





WHO IS WINNING?





SUMMARY OF INDIRECT METHODS

- The transit method relies for the observer, the exoplanet, and the star to be on the same plane
- Other methods don't require a perfect plane, though it may be easier, can't be viewed when perpendicular
 - Radial velocity
 - Orbital brightness modulus
- The microlensing method only requires that a distant star at some point gets in line with the exoplanet and the observer



QUESTIONS?

- What method do you think will prevail as the most prolific method in the next 100 years?
- What is another astrophysics topic that can be studied through microlensing?
- What method would be employed in the search of an “Earth-like” planet?

REFERENCES

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