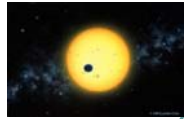


Extrasolar Planets

Astro12: The Planets
Ray Luo



Exoplanets

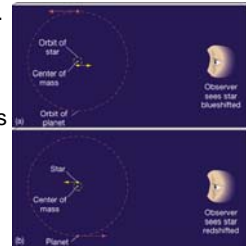
- 102 planet systems, 117 planets found.
- Astrodynamics Group of Vienna.
- Center for Integrative Planetary Science.
- Kompetenzzentrum Extrasolare Planeten of Jena and Tautenburg, Germany.
- Barnard's star and Van de Kamp's planets.
- 1952 proposal by Otto Struve of Berkeley for high-precision stellar radial velocity work.

Recent History

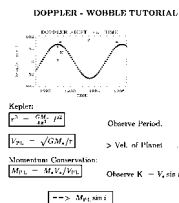
- 1994 Swiss-French analysis of 51 Pegasus 40 light-years away.
- Upsilon Andromedae the first three-planet system.
- HD 209458 revealing drop in brightness every 3.5 days.
- Kepler Mission to monitor 100,000 stars for brightness fluctuation.

Detection Methods

- Doppler Spectroscopy.
- Fluctuations in radial velocity picked up by the Doppler Effect.
- Measure Doppler shifts greater than 3m/s.
- Only a lower bound on mass of planet.
- Observation assumed along line of sight.



Detection Methods



Detection Methods

- Transit photometry.
- Periodic dimming of the star produced by planet passing in front of it along line of sight.
- Detectable size about half size of Earth for a 1 AU orbit about a 1M₀ star.



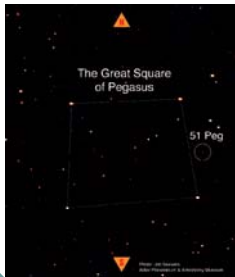
Detection Methods

- Pulsar Timing: for planets orbiting a pulsar, measure variation in pulse arrival; older method.
- Astrometry: periodic wobble that a planet induces in transverse position of star; no planet detections confirmed using this method.

51 Pegasus

- Contains first exoplanet to be discovered.
- Radial velocity goes from -50 m/s to +50 m/s with period of 4.15 days.
- 0.05 AU semi-major axis.
- 0.5 Jupiter mass.
- At estimated 3000 K, don't expect gaseous planet to form by accretion.
- Formed by condensation as for stars.
- A G-dwarf brown dwarf binary system?
- <http://zebu.uoregon.edu/51peg.html>

51 Pegasus

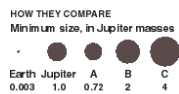
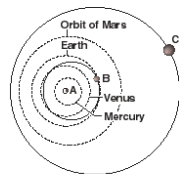


51 Pegasus

- Geneva group class IV star program.
- Michel Mayor and Didier Queloz.
- Based on Doppler measurements done with ELODIE spectrograph of Observatoire de Haute-Provence.
- Not sensitive to planetary orbital induced variations, but good for pulsational radial velocity variations.
- Confirmed by Geoffrey Marcy (Lick, Berkeley).
- Differential Photometry.

Upsilon Andromedae

- Orbited by 3 large planets.
- Found by Marcy's group.
- 4.6, 242, and 1269 day periodicities of velocity.
- Expect 6200 K!

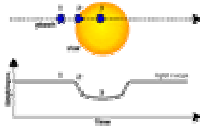


Upsilon Andromedae



HD 209458

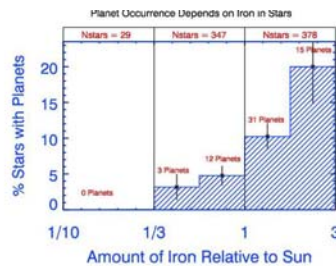
- First extrasolar planet to show transits across the disk of its star HD 209458.
- Dave Charbonneau and Tim Brown (STARE).



California & Carnegie Planet Search

- Supported by NASA, Sun, and NSF.
- Occurrence of planets correlates with stellar metal content.
- Planet orbiting HD 70642 nearly like Jupiter.
- Hydrogen atmosphere on planet around HD 209458.
- http://exoplanets.org/planet_table.txt

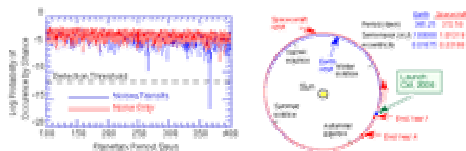
Iron Dependence



Kepler Mission

- Transit-based discovery of terrestrial (rocky, Earth-sized) exoplanets.
- Differential photometry: brightness of target normalized to average of nearby stars.
- Matched filter algorithm for signal detection: controlling for noise.
- Schmidt telescope (correcting lens for entire field of view) on spacecraft orbiting the Sun.
- Proposed 4 year mission: launch 2007.

Kepler Mission



Implications

- Generally "hot" Jupiters orbiting other stars with small and eccentric orbits.
- Selection effect: massive planets are the only ones we can observe.
- Likely to form according to our theory?
- What's typical, our system or those found?
- Jupiter started with eccentric orbits then moved outward, perhaps most "Jupiters" don't move out.
- Need to find Earth-sized planets.