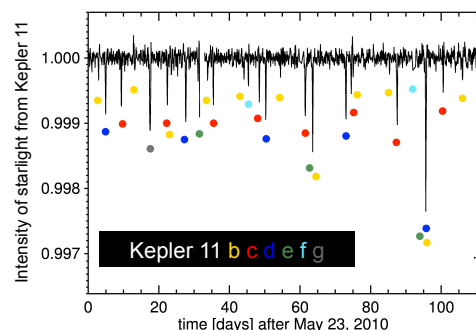


Discovery of A Six-Planet System

- NASA's Kepler spacecraft searches a small portion of the sky for periodic dimming of more than 150,000 stars in our Milky Way galaxy, indicating planets may be passing in front of (*transiting*) them
- A system of 6 planets was recently reported orbiting a single star named Kepler 11
- The planets are among the smallest discovered around other stars. Their properties challenge theories for planetary formation.



The amount of light from the star Kepler-11 decreases when each of six planets (denoted by the six circle colors) passes in front of it. Note that each planet's transit occurs at regular intervals.

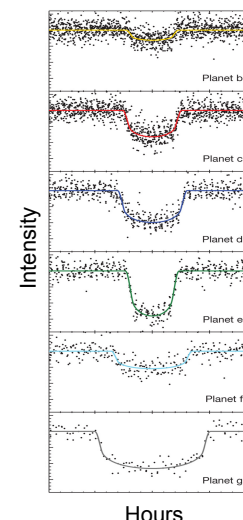
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Finding Planet Sizes and Masses

- The starlight dimming tells us:
 - Size: 2-5 times Earth's size (from amount of dimming)
 - Orbital period: 10-120 days (from frequency of dimming)
 - Orbital distance: 0.1-0.5 Earth's (from period and Kepler's 3rd Law)
 - Mass: 2-15 Earth masses* and Orbit shape: nearly circular* (from simulations of transits being early or late by minutes, caused by the planets nudging each other gravitationally)
 - Density: 0.1-0.6 times Earth density* (mass / volume)

* Can only be determined for the 5 inner planets



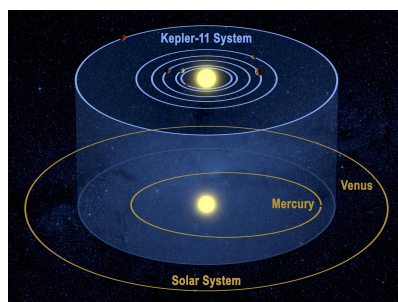
The amount of light measured from Kepler 11 for each transit allows scientists to infer many properties of the six planets

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The Big Picture

- Knowledge of the planets' orbits and characteristics allows scientists to constrain their composition and evaluate scenarios for their formation
- The planets are less dense than Earth, implying they have substantial amounts of gas, or possibly ice
- But they are also close to their star where temperatures are high, making it harder for them to keep gas or ice
- Recent discoveries are highlighting diverse population of exoplanets - forcing scientists to rethink theories for planetary formation



Schematic view of the Kepler-11 planetary system (blue), with the orbits of Venus and Mercury shown for reference. How did such a compact, circular, flat system of low-density planets form?

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For More Information...

Press

- Space.com - 02/02/10 - "Astronomers Find 6-Pack of Planets in Alien Solar System" <http://www.space.com/10744-alien-planets-solar-system-kepler-mission.html>
- Sky & Telescope - 02/02/11 - "Kepler's Outrageous Six-planet System" <http://www.skyandtelescope.com/news/115102594.html>
- NASA Kepler - 02/02/11 - "NASA's Kepler Spacecraft Discovers Extraordinary ..." http://www.nasa.gov/mission_pages/kepler/news/new_planetary_system.html
- NASA Kepler Mission Site - 02/01/11 - "NASA Announces 1,235 Planet Candidates, ..." <http://kepler.nasa.gov/news/index.cfm?FuseAction=ShowNews&NewsID=98>

Images

- Slide 1 image courtesy Daniel Fabrycky and the Kepler team, based on: <http://www.nature.com/nature/journal/v470/n7332/full/nature09760.html>
- Slide 2 image from Lissauer et al., Nature article <http://www.nature.com/nature/journal/v470/n7332/full/nature09760.html>
- Slide 3 image courtesy NASA / Tim Pyle http://www.nasa.gov/mission_pages/kepler/news/new_planetary_system.html

Source Articles (on-campus login may be required to access journals)

- Lissauer et al., 'A closely packed system of low-mass, low-density planets transiting Kepler-11', *Nature*, 470, doi:10.1038/nature09760, 2011. <http://www.nature.com/nature/journal/v470/n7332/full/nature09760.html>

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