

Kepler and the Transit of Venus

The Kepler Mission: Is Earth unique in the universe? How many Earth-size planets exist? NASA's *Kepler Mission* seeks to answer these questions by searching for Earth-size planets orbiting in the habitable zone of Sun-size stars. Launched in 2009, the *Kepler* spacecraft is a specialized telescope that acts like a very precise light meter, a photometer. By precisely measuring changes in a star's brightness, the *Kepler* team discovers planets as they cross in front of their stars. This is the "transit method" for detecting planets. It stares continuously at more than 150,000 stars so it won't miss a transit. From the transit data, scientists can determine the size of the planet, the length of its year, and calculate the planet's distance from its star. Combined with Earth-based observations, the planet's mass, density and possible surface temperature can be determined. A scientist's artistic rendition of the 1,235 planet candidates transiting their stars appears on the front of this poster. To see the smallest planet candidates, go online for higher resolution images.

Investigation: Transit Tracks

The *Kepler Mission* observes exoplanets transiting distant stars. Each transit makes a "track" as the exoplanet crosses in front of its star. The "track" is revealed as a dip in the graph of the star's brightness over time. This is called a light curve. Each time the planet transits, the light from the star dips.

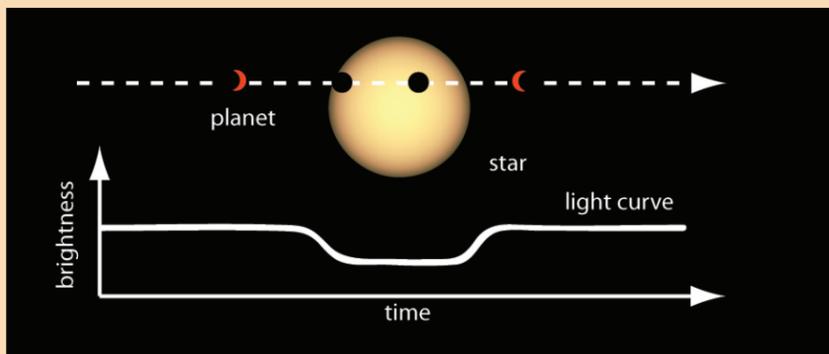


Figure 1: Light curve of a planet transiting its star.

By measuring the depth of the dip in brightness and knowing the size of the star, *Kepler* scientists can determine the size of the planet. From measuring the time elapsed between repeated transits, *Kepler* scientists can find the time it takes an exoplanet to orbit its star. One orbit is the planet's year-length which, using Kepler's Third Law, gives us the average distance of the exoplanet from its star. Figure 2 shows the light curves for an exoplanet named Kepler-5b.

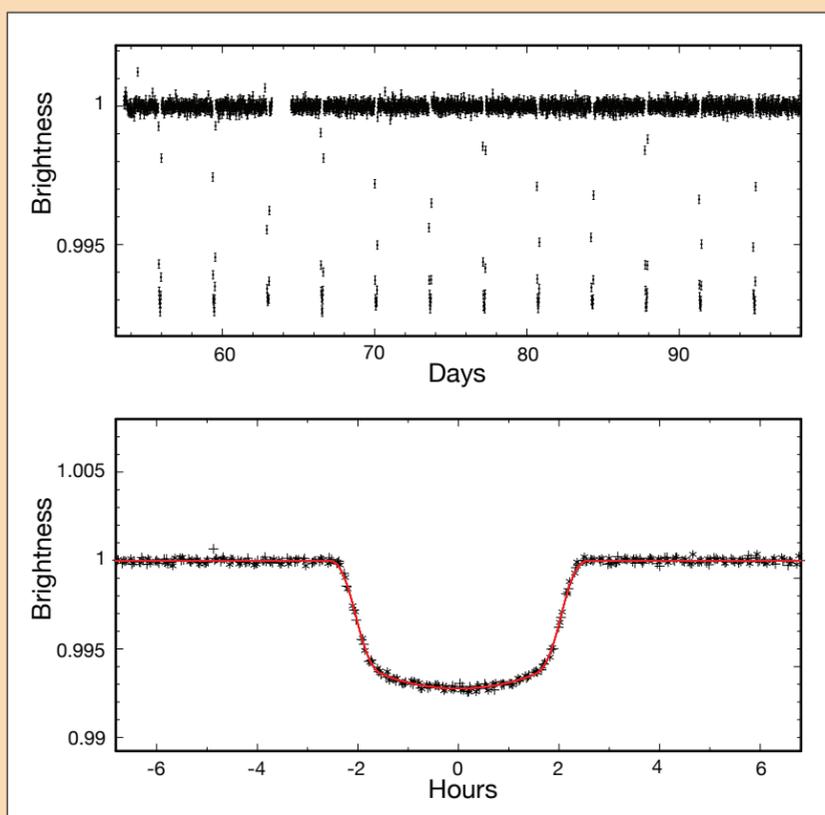
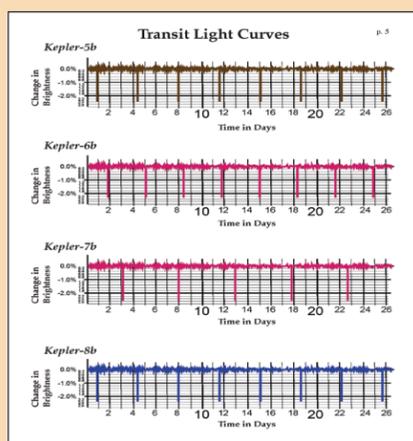


Figure 2: The light curves for confirmed planet, Kepler-5b show repeated transits (upper) and a close-up of all the transits combined (lower).

Students can interpret light curves to deduce the exoplanet's size, year-length, and average distance from its star. Then, they can go to the *Kepler Mission* website to learn more about the planet they analyzed by starting at the "Discoveries Table." It links to information about individual exoplanets. The "Discoveries Table" is found at: kepler.nasa.gov/Mission/discoveries/. Click on individual planet names to learn more.

Transit Tracks uses light curves adapted from actual *Kepler Mission* data. The lesson instructions, supporting materials, and *Kepler Mission* presentation materials for *Transit Tracks* can be downloaded at kepler.nasa.gov/education/activities/transitTracks/

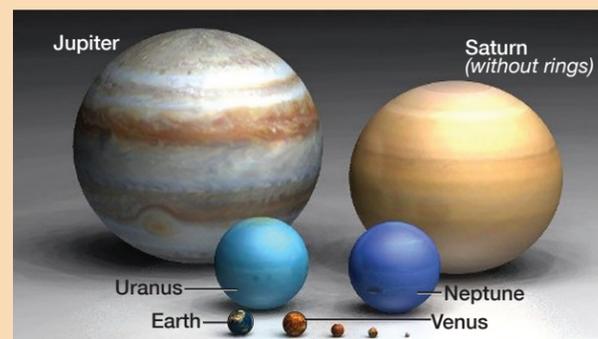


A sample page from Transit Tracks lesson.

Transit of Venus: The *Kepler Mission* is named for Johannes Kepler (1571 -1630), who is often honored as the first astrophysicist. He was a German astronomer and mathematician and whose Laws of Planetary Motion were key discoveries in establishing modern science. Laws I and II show that planetary orbits are elliptical and that the orbital speed of a planet varies according to its distance from the Sun. Law III states that the average distance (semi-major axis) of a planet from the Sun can be calculated from the planet's year-length. Today, *Kepler Mission* scientists still use Law III to figure out how far an exoplanet is from its star. In 1627, Kepler published the *Rudolphine Tables*, a star catalog and tables of planetary positions, and first predicted the transits of Mercury (1631) and Venus (1639). Johannes Kepler did not live to see the transits, but others did. The *Kepler Mission* uses transits to discover planets circling distant suns. Surely, Johannes Kepler would be pleased and amazed.



Credit: Jan Herold (German Wikipedian)



Artist's depiction of the planets in our Solar System. Compare the size of Venus with the other planets.

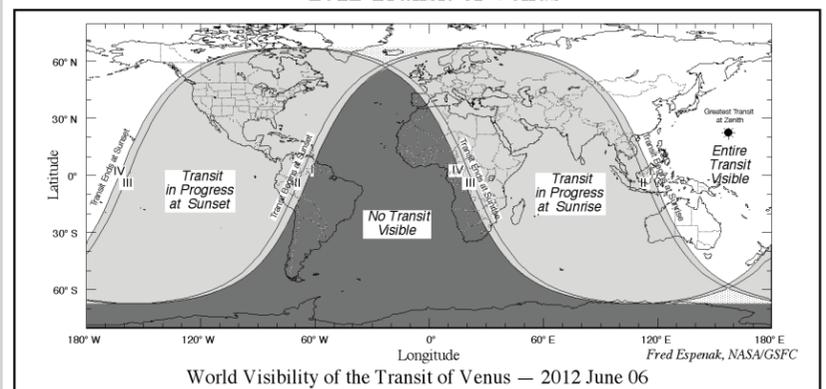
The image above is a photograph of the transit of Venus taken on June 8, 2004.

Credit: unknown source

No Transit Visible?

Not everyone on Earth can view the transit of Venus in 2012. Do you live where the transit will not be visible? You'll be able to see many stars that are known to have planets. (See the *Kepler Star Wheel* in "*Kepler Online Resources*.") Using a telescope equipped with sensitive detectors, it is possible to make transit observations of large, Jupiter-size exoplanets in the *Kepler* search area. More than 100 exoplanets will be transiting their suns during the time that the transit of Venus is occurring in our solar system. To download a table of transiting planets, go to: spacemath.gsfc.nasa.gov/SED12/KeplerVenus.pdf

2012 Transit of Venus



Kepler Online Resources: Learn More, Do More, Link Up

The 1,235 Planet Candidates in Hi-Res: look for Earth-size planets	kepler.nasa.gov/images/graphics
<i>Kepler Exoplanet Discoveries</i> : learn more about discoveries	kepler.nasa.gov/Mission/discoveries/
<i>Making Transits</i> : demonstration and modeling	kepler.nasa.gov/education/activities/gr68/detectingPlanetTransits/
<i>Explore the Kepler Planet Candidate Data</i> : dive into data	kepler.nasa.gov/dataexplorer
<i>Planet Hunters</i> : join citizen scientists seeking planets	www.planethunters.org
<i>Kepler in the News</i> : popular press and announcements	kepler.nasa.gov/news/nasakeplernews/
<i>Kepler Planet Simulator</i> : learn the steps to discovery	kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery/
<i>Build a Model Kepler Spacecraft</i> : get crafty	kepler.nasa.gov/education/ModelsandSimulations/papermodel/
<i>Kepler Star Wheel</i> : find stars with exoplanets	kepler.nasa.gov/education/starwheel/
<i>Lessons and Activities</i> : learn and have fun	kepler.nasa.gov/education/
<i>Space Math</i> : stretch your brain	spacemath.gsfc.nasa.gov/SpaceMath.html
<i>Who Was Johannes Kepler?</i> hint: he lived long ago!	kepler.nasa.gov/Mission/JohannesKepler/
<i>Get Ready for the Transit of Venus</i> : make your plans	www.transitofvenus.org/
<i>Twitter</i> : get official Kepler Mission tweets	@NASAKepler
<i>Facebook</i> : join the crowd!	www.facebook.com/NASAsKeplerMission

Credits:

Who's involved with the *Kepler Mission*? NASA's *Kepler Mission* involves many careers including scientists, engineers, computer programmers, program managers, financial analysts, technicians, educators, and students. Learn more about the people of the *Kepler Mission* at kepler.nasa.gov/mission/team/

The *Kepler Mission* is lead by the *Kepler Science Office* at NASA Ames Research Center, Moffett Field, CA. The *Kepler Education and Public Outreach* program is led by the Lawrence Hall of Science, UC Berkeley, and the SETI Institute. For more information on the *Kepler Mission*, visit kepler.nasa.gov and www.nasa.gov/kepler