Kepler Space Telescope

Content Option 3: Mission Review

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Abstract

This paper explores the mission, objectives, equipment and scientific discoveries of the Kepler Space Telescope. Kepler is NASA's first mission to survey a region of the Milky Way galaxy to discover habitable planets like our Earth. The mission has established clear evidence of a large number of exoplanets, planets outside of our solar system, that are orbiting other stars in our galaxy. The information collected in this study will be used as a basis for lectures conducted by the author to high school students in grades freshman through senior year. Science, Technology, Engineering and Math (STEM) lesson plans using the NASA Exoplanet Archive will continue to be developed to expand students' knowledge in the subject of Astronomy and Space Science.

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The Kepler Space Telescope is named after Johannes Kepler, a German mathematician and astronomer born in 1571. He has been credited with a series of "firsts" including the correct explanation of planetary motion, the explanation of how a telescope works and the first to explain that the tides are caused by the Moon. In 1601, Johannes Kepler inherited the post of Imperial Mathematician succeeding Danish astronomer Tycho Brahe. Kepler continued the analysis of Brahe's body of data collected during the study of the orbit of Mars. It was through the analysis of this data that Kepler concluded that the orbit of Mars is an ellipse. The scientific method as we know it today is attributed to Kepler's accurate analysis of Brahe's large collection of data to verify a fundamental law of nature (NASA Ames Research Center, 2013).

The goal of the Kepler Mission is to survey a region of the Milky Way galaxy to discover habitable planets like our Earth. The search for exoplanets, defined as planets outside of our solar system that are in the "habitable zone" of other stars in our galaxy, has yielded a remarkable archive of confirmed planets. The habitable zone is defined as, "…the range of distances from a star where liquid water might pool on the surface of an orbiting planet" (NASA Science, 2014). As of the date of this writing, the NASA Exoplanet Archive has confirmed 1,732 exoplanets orbiting stars in the Milky Way galaxy.

The Kepler Space Telescope was launched from Cape Canaveral Air Force Station adjacent to Kennedy Space Center in Florida on March 6, 2009 aboard a Delta II Rocket. The original planned duration of the mission was three and a half years (NASA Mission Pages, 2014).

The Kepler telescope instrument is called a photometer which is a device that measures the brightness of light. The diameter of the photometer is 0.95 meters and works by recognizing minuscule “dips” in the brightness of a star being studied. The “dip” represents a planet passing in front of the star. When a planet crosses in front of its star, the event is called a “transit”. Once a transit of a planet in front of a star being studied has been detected, then the planet’s orbit can be calculated by recording how long it takes the planet to orbit once around its star. The size of the planet is determined by how much the brightness of the star dips as compared to the size of the star itself. Calculations of the planet’s temperature are made using the size of the orbit of the planet and the temperature of the star. This is important in order to determine if the planet is habitable (NASA Ames Research Center, 2014).

The largest camera that has ever been launched into space is also contained within the instrumentation of Kepler. The device is configured with a 95-megapixel array of charge-coupled devices (CCDs) similar to those that are housed in a personal digital camera. An iPhone 5S contains an 8-megapixel camera (Apple, 2014). The CCD is a photon detector comprised of a thin silicon wafer that is organized into an array of light-sensitive regions that capture light and store image information (Spring, 2014). According to NASA’s Imagine the Universe Dictionary, a photon is, “The smallest (quantum) unit of light/electromagnetic energy. Photons are generally regarded as particles with zero mass and no electric charge”(NASA, 2014). The Kepler data is stored onboard and downloaded once per month via NASA’s Deep Space Network (DSN). The DSN is an international network of antennas in California, Spain and Australia (NASA Ames Research Center, 2013).

The Cygnus-Lyra region of the Milky Way is continuously monitored by the Kepler telescope. This area of the galaxy was chosen because it provides more than 100,000 stars to examine for planetary "transits" (NASA Ames Research Center, 2013). Within the first forty-three days of the mission, five exoplanets were confirmed by the Kepler science team. A significant discovery was announced in September 2011 when an exoplanet was confirmed to be orbiting two stars. This type of orbit is called "circumbinary" (NASA Discovery Program, 2014). On April 14, 2014, two months preceding this writing, NASA reported that an earth-size planet was found in the habitable zone of another star. This is significant because the planets previously found in the habitable zone were forty percent larger than our earth. The planet, called Kepler-186f, orbits its parent star once every one hundred and thirty days and is exposed to one-third the energy that we receive from our sun. Kepler-186f is approximately 500 light years (1 light-year is equivalent to 9.46053×10^{12} km) from Earth and resides in the Cygnus constellation (NASA Science, 2014).

A frequently asked question about Kepler is whether a manned mission will ever attempt to visit a confirmed exoplanet. The answer is currently no since the closest star is four light-years away from earth and would take thousands of years to reach with spacecraft speeds that we can currently achieve. However, two NASA missions are being planned that could detect light directly from a confirmed exoplanet to determine data about atmosphere and life forms. The two missions are the Space Interferometry Mission and the James Webb Space Telescope (NASA Ames Research Center, 2013).

Conclusions and Further Study

The NASA Exoplanet Archive provides an Application Programming Interface (API) webpage that can be used by programmers to build data queries of Confirmed Planets, Kepler Objects of Interest (KOI), Threshold-Crossing events, Kepler Names/Kepler Stellar Properties/ Kepler Time Series and SuperWASP (NASA Exoplanet Archive, 2014). Valuable resources such as query syntax and examples of valid queries provide a wealth of information for a programming student building a webpage or application to investigate the findings of the Kepler Space Telescope. This type of STEM data-driven exercise will yield meaningful understanding of the subjects of astronomy and space science. Graphing of resulting data can exercise students' mathematical skills. Investigations of the storage and transmissions of images can reinforce engineering concepts. Technology is implemented through the successful API queries displayed on webpages constructed by students in HTML5 designed with cascading style sheets or iOS Apps that load resulting data into table view controllers.

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