Detecting Planets Around Other Stars

Cody Dirks and Bonnie Weiberg

Purpose

This activity is intended to show students how astronomers are able to find planets orbiting stars other than our Sun, using a simple NetLogo simulation that replicates a planet orbiting a star and produces simulated data that the *Kepler* satellite would see. This activity utilizes some basic equations regarding orbital motion and Kepler's Laws, allowing students to see the connection between these simple equations and their real-world implications on astronomical data used in current research.

Overview

1) Students will first be shown a brief PowerPoint about the *Kepler* satellite, giving some basic information about how it operates, and introduce them to the idea of a "light curve," which will be the main data shown during the simulation. (5-10 minutes)
2) Students will be then introduced (and given a quick overview) to the NetLogo simulation, and given the accompanying worksheet that both lists detailed information about the simulation, and provides some questions for the students to work on. (5 minutes)
3) Students get to interact with simulation, and use it to answer questions on the worksheet. (30 minutes)

Student Outcomes

- Explain how the *Kepler* satellite looks for the presence of planets orbiting other stars.
- Understand what a "light curve" is, and identify basic features present in a sample light curve.
- Understand the connection between the features of a light curve and the physical parameters of a planet's orbit.

Standards Addressed

- **HS-ESS1-4** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- **Developing and Using Models**
- **Using Mathematical and Computational Thinking**

Time

45 minutes (1 class period)

Level

High school, regular (non-AP) Physics.

Materials and Tools

PowerPoint about *Kepler* (Kepler Slideshow.pptx)
NetLogo simulation (lightcurve.nlogo)
Handout with questions (Detecting Planets Around Other Stars.pdf)

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Preparation
Computers in classroom will need to have NetLogo software installed on them to run the simulation.

Prerequisites
None.

Background
This lesson will deal with Kepler's Laws, specifically Kepler's Third Law, which says that there is a connection between how far a planet is from its star, and how long it takes to orbit around the star (also called the period). So if we can find a way to measure the period of a planet, we can find out how far away from its star it is. In this lesson we will look at one way that astronomers find the period of planets around other stars (these are called “exoplanets”), allowing us to learn information about planets that are thousands of light-years away.

Teaching Notes
1) PowerPoint about the *Kepler* satellite (5-10 minutes)
Details about the *Kepler* satellite (size, mass, where in the sky it is pointing). Explain that *Kepler* gathers data by repeatedly taking images of the exact same region of the sky, measuring the brightness of each of the 100,000+ stars in that region of the sky. These measurements of brightness for each star are then plotted on a graph of Brightness vs. Time, and scientists then look for any periodic changes in brightness resulting from a planet passing in front of the star and blocking out some of the starlight. The *Kepler* satellite and the scientists working with its data have detected thousands of new planets using this method.

2) Intro to NetLogo simulation (5 minutes)
Students are given a quick overview of the elements of the simulation – its sliders change parameters of the planets orbit, the “world” window displays a visualization of the planet passing in front of the star, and the light curve graph plots the brightness in real time. This time axis of this graph is either in total time since the simulation began, or students can choose to “fold” the light curve. In this case, the time axis is the length of one orbit, and the data is looped back to the beginning of the graph at the end of each orbit, making any features of the graph much more prominent.

3) Students use simulation and answer questions (30 minutes)
Students are given free reign to play with the simulation for the remainder of the course. The questions on the handout are intended to push them to explore all aspects of the simulation, and see how their choices for input parameters affect the light curve. Instructor spends this time wandering the room, making sure students are on task and answering any questions.

Assessment
Class Participation
Collecting questions from handout at the end of class (could also be homework assignment if students have access to NetLogo outside of classroom)

Additional Information
None.