NATIONAL GEOGRAPHIC

Activity*develop*

Hunting for Planets

How can you use star brightness to find planets?

Overview

Students discover how scientists use the transit method to detect planets. Using interactive models, they investigate how a star's light intensity changes based on the effects of planet size and angle of orbit. Next, they explore the effect of data noise on detection. Finally, students challenge each other to find planets based only on data from velocity and light intensity graphs.

For the complete activity with media resources, visit:
http://nationalgeographic.org/activity/hunting-planets/

Content Created by

The Concord Consortium

Directions

1. Engage students in a discussion about eclipses.

Explain to students that in a solar eclipse, the Moon moves directly between the Earth and Sun. Tell them that an eclipse may be total, in which the Moon appears to block the entirety of the Sun, or partial, in which the Moon blocks only a part of the Sun. Ask:

- *What happens to the Sun's brightness, as seen from Earth, during a solar eclipse?* (When the Moon moves between the Sun and Earth, the Sun appears to dim.)
- *Which type of eclipse causes more dimming effect, as seen from Earth: a partial eclipse or a total eclipse?* (A total eclipse will cause more dimming because the entire face of the star is blocked. During a partial eclipse, there is less dimming because the Moon does not completely obscure the Sun.)

Tell students that scientists use planetary eclipses to find planets around stars. As the planets move around their stars, they can block some of the light from that star, just as our Moon can block light coming from our Sun during a solar eclipse.

2. Discuss the role of uncertainty in the scientific process.

Introduce students to the concept of uncertainty in the scientific process. Explain that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. Tell students that they can see examples of scientists' uncertainty in determining whether or not the data collected from telescopes show the presence of planets.

Show the **Kepler Planet Candidates graph** from the NASA Exoplanet Archive. Tell students that the red dots indicate potential planets the Kepler telescope has detected and the blue dots indicate the planets the Kepler telescope detected and have been confirmed by other means. Ask:

- *Why do you think there are more red dots than blue dots (more potential planets than confirmed planets)?* (The telescope may detect planets that are not there. The technology may not be good enough to tell the difference between a planet and some other phenomenon.)
- *Why do scientists need to independently confirm the presence of planets?* (Scientists need to check the accuracy of the telescope's predictions of a planet. If the telescope shows a planet and the scientists confirm that it is a planet, then the scientists can spend more time trying to learn about the planet.)

Let students know that they will be asked questions about the certainty of their predictions and that they should think about what scientific and model-based data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce and discuss the use of computational models.

Explain the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. Project the NOAA Weather Forecast Model, which provides a good example of a computational model. Tell students that scientists use planetary models to predict the motion and apparent brightness of stars if planets are present and to predict the habitability of planets. Explain that there are many different types of models and that they will be using simple models of planetary motion in this activity.

4. Have students launch the Hunting for Planets interactive.

Provide students with the link to the Hunting for Planets interactive. Divide students into groups of two or three, with two being the ideal grouping to allow students to share computer work stations. Tell students they will be working through a series of pages of data with questions related to the data. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Tell students this is Activity 3 in the **Is There Life in Space?** lesson.

5. Discuss the issues.

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *How does a planet's size affect its ability to be discovered via the transit method?* (The transit method relies on detecting dimming of a star as planets orbit. If the planet is very large, it can block more of the light coming from the star. A high level of dimming is easier to detect than a smaller level of dimming. Therefore, larger planets are more likely to be detected than smaller planets.)
- *How does the angle of orbit affect a planet's ability to be detected?* (A planet needs to orbit in the same plane as the scientists' telescopes to be able to be detected reliably. This is particularly important when using the transit method. If the telescope is even slightly out of the orbital plane, the dimming will not be detected. The wobble (radial velocity) method is more robust, since that depends on detecting motion (wavelength shift) of the star, not the brightness of the star.)
- *How does telescope "noise" affect planet hunting?* (Scientists are more likely to discover larger, heavier planets than smaller, lighter ones because of the effect of telescope noise. The signals from smaller, less massive planets are smaller than the signals from larger, more massive planets. The smaller signals can get lost in the data "noise," making it difficult to determine whether a planet is present.)

TipTeacher Tip

To save your students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

The activity is part of a sequence of activities in the Is There Life In Space? lesson. The activities work best if used in sequence.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an

LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking students the following questions:

- How are planets found via the transit method?
- Why can't scientists use the transit method to find planets orbiting at a 45-degree angle?
- If there is no dip in a star's light intensity, does that mean that there is not a planet orbiting that star?
- How does a planet's diameter affect scientists' ability to detect it via the transit method?
- How does a planet's size affect whether it can be discovered via the transit method?
- How does the angle of orbit affect whether a planet will be detected via the transit method?

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- Space sciences

Learning Objectives

Students will:

- explain how planets can be detected using the transit method
- describe how a planet's diameter affects its ability to be detected via the transit

(light-intensity) method
- describe how the tilt (orbiting angle) of a planet affects its ability to be detected via the transit method
- explain how technological advances can result in new scientific discoveries

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-paced learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

NCTM Principles and Standards for School Mathematics

• **Algebra (9-12) Standard 1:**
Understand patterns, relations, and functions
• **Algebra (9-12) Standard 2:**
Represent and analyze mathematical situations and structures using algebraic symbols
• **Algebra (9-12) Standard 3:**
Use mathematical models to represent and understand quantitative relationships

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-2:**
Motions and forces
• **(5-8) Standard E-2:**
Understandings about science and technology
• **(5-8) Standard F-5:**
Science and technology in society
• **(5-8) Standards 8AI1.3:**
Use appropriate tools and techniques to gather, analyze, and interpret data
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-4:**
Motions and forces
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

- **CCSS.ELA-LITERACY.RST.9-10.1.:**
Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
- **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3

ISTE Standards for Students (ISTE Standards*S)

- **Standard 3:**
Research and Information Fluency
- **Standard 4:**
Critical Thinking, Problem Solving, and Decision Making

Next Generation Science Standards

- **Crosscutting Concept 1:**

Patterns
• **Crosscutting Concept 2**:
Cause and effect: Mechanism and prediction
• **Crosscutting Concept 3**:
Scale, proportion, and quantity
• **Crosscutting Concept 4**:
Systems and system models
• **Crosscutting Concept 7**:
Stability and change
• **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea)**:
The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)
• **ESS1.B: Earth and the Solar System (Disciplinary Core Idea)**:
Kepler’s laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)
• **PS2.A: Forces and Motion (Disciplinary Core Idea)**:
For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).
• **PS2.B: Types of Interactions (Disciplinary Core Idea)**:
Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the sun. (MS-PS2-4)
• **Science and Engineering Practice 1**:
Asking questions and defining problems
• **Science and Engineering Practice 2**:
Developing and using models
• **Science and Engineering Practice 3**:
Planning and carrying out investigations
• **Science and Engineering Practice 4**:
Analyzing and interpreting data
• **Science and Engineering Practice 5**:
Using mathematics and computational thinking
• **Science and Engineering Practice 6**:

Constructing explanations and designing solutions
• **Science and Engineering Practice 7**:
Engaging in argument from evidence
• **Science and Engineering Practice 8**:
Obtaining, evaluating, and communicating information

Preparation

What You'll Need

Materials You Provide

- Computers (either one per student or one per group of two students)
- Internet access

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per small group, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Handouts & Worksheets

- Answer Key: Hunting for Planets

Resources Provided: Images

- Kepler Planet Candidates Graph

Background & Vocabulary

Background Information

Scientists can use the light from stars to detect orbiting planets. The light from the star appears to dim when the planet crosses between the star and the telescope. This is similar to a solar eclipse when the Moon moves between the Sun and the Earth. This results in an apparent dimming of the light from the Sun.

The easiest planets to detect via the transit method are those that cause the most dimming of the star. The larger the planet size, the more it will dim the light from the star.

The angle of a planet's orbit will affect whether or not scientists can detect the planet. If the planet is in the same plane as the telescope, the dimming will be most readily detected. But if the planet orbits at a right angle to the telescope, the dimming of the star will not be detected by the telescope. Whether or not an obliquely orbiting planet will be detected by a telescope depends on its size. The transit method is more sensitive to angle of orbit than the wobble method.

Prior Knowledge

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Recommended Prior Activities

- Moving Stars and Their Planets
- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
eclipse	*noun*	an event where one heavenly body obscures the light of another.
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.
mass	*noun*	measure of the amount of matter in a physical object.
outer space	*noun*	space beyond Earth's atmosphere.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
precision	*noun*	exactness.
solar system	*noun*	the sun and the planets, asteroids, comets, and other bodies that orbit around it.
telescope	*noun*	scientific instrument that uses mirrors to view distant objects.

For Further Exploration

Articles & Profiles

- National Geographic: This Day in Geographic History: November 27, 2001 Atmosphere on Extrasolar Planet Detected

Images

- National Geographic: Illustration: Media Spotlight: Orbital plane

Reference

- National Geographic: Encyclopedic Entry: Planet
- Wikipedia: Methods of Detecting Exoplanets
- National Geographic: Encyclopedic Entry: Orbit

Video

- TED Talk: Tabetha Boyajian: The most mysterious star in the universe

Websites

- Wikipedia: Transit photometry
- NASA Jet Propulsion Laboratory: PlanetQuest

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This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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