Activity*develop*

Moving Stars and Their Planets

How can you use star movement to find planets?

Overview

Students investigate how scientists use Newton's Third Law of Motion to infer the presence of a planet orbiting a star. They explore the Doppler effect, the influence various factors have on the ability to detect an orbiting planet, and the effect of telescope noise and data imprecision on scientists' ability to find planets around stars.

For the complete activity with media resources, visit:
http://nationalgeographic.org/activity/moving-stars-and-their-planets/

Content Created by

The Concord Consortium

Directions

1. Activate students' prior knowledge about Newton's Third Law of Motion.

Tell students that for every action, there is an equal and opposite reaction. Ask:

- *Imagine you have a dog on a leash. When the dog pulls on the leash, what do you feel?* (When the dog pulls on the leash, you feel a pull towards the dog.)

- *What does the dog feel?* (The dog feels an equal force pulling it back towards you. The force is equal to and opposite of the force that you feel in the leash.)

Explain to students that scientists use this concept to find planets orbiting around stars. Tell students that the gravitational pull of planets can move their stars as they orbit.

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 Moving Stars and Their Planets interactive .

Provide students with the link to the Moving Stars and Their 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 2 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 them in a discussion focusing on these questions:

- *What is the Doppler effect?* (The Doppler effect is the apparent change in wavelength as an object moves. As the object moves closer, the wavelength decreases, and as the object moves away, the wavelength increases.)

- *How do scientists use the Doppler effect to find planets around a star?* (Planets pull on their stars as they orbit, thus moving the star. If the star is in the same plane as the observer, the observer can see that the light coming from the star appears to become redder as the star moves away and bluer as the star moves closer. The changing wavelengths indicate that the star is moving. If this movement is regular, it is likely that a planet is causing the star to move.)

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.

Tip

You can save student data for grading online by registering your class for free at the High-Adventure Science portal page.

Informal Assessment

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

- How are planets found via the wobble method?
- How does a planet's mass affect its star's wobble?
- How does the angle of orbit affect whether a planet will be detected?

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 changes in the light coming from a star allow scientists to detect its motion
- describe how planets are found using the wobble method
- describe the effect of planetary mass on a star's wobble
- explain how the angle of a planets' orbit around a star determines whether the planet might be found

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

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) Standard G-1:**
Science as a human endeavor
• **(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 F-6**:
Science and technology in local, national, and global challenges
• **(9-12) Standard G-1**:
Science as a human endeavor

Common Core State Standards for English Language Arts & Literacy

• **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**:
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12**:
Key Ideas and Details, RST.6-8.3
• **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.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

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
- **ESS1.A: The Universe and Its Stars (Disciplinary Core Idea):**
Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)
- **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

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per pair, 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: Moving Stars and their Planets

Resources Provided: Images

- Kepler Planet Candidates Graph

Background & Vocabulary

Background Information

Scientists use the Doppler effect to detect star motion. As a star moves towards you, the wavelengths appear to get shorter (blue shift). As the star moves away from you, the wavelengths appear to get longer (red shift). Scientists use these shifts in wavelength to determine the motion of stars relative to their telescopes.

Stars' motion is caused by gravitational interactions with other celestial bodies. As a planet orbits a star, the planet “tugs on” the star. This demonstrates Newton’s Third Law of Motion, which states that for every action, there is an equal and opposite reaction. Depending on the sizes of the planet and star, the planet may cause the star to visibly move. Thus, star motion can indicate an orbiting planet. (Even if it can't be seen, all planets have an effect on their stars' motions.)

Planetary mass affects the amount of star movement. The more gravity that the planet has, the more it will move its star. Rocky planets are denser than gaseous planets, so a large rocky planet will have more effect on star motion than a large gaseous planet.

The angle of a planet's orbit will affect whether or not scientists can detect the planet. If the planet's orbit is in the same plane (line-of-sight) as the telescope, the movement of the star will be most readily detected. But if the planet orbits at a right angle to the telescope, the motion of the star will not be detected by the telescope because the star will not be moving toward or away from the telescope. Whether or not a telescope will detect an obliquely orbiting planet depends on the planet’s mass.

Telescopes used to detect star motion are imprecise. Interference from our atmosphere, as well as space dust and gases (sometimes referred to as “noise”), also blur the telescopes' vision. The data from these telescopes are “noisy,” and it can be difficult to detect star motion beyond the background noise. If a planet does not cause a large change in star motion, current telescopes may not detect it. However, with technological advances, scientists will be able to detect smaller star motions, and, therefore, smaller planets.

Prior Knowledge

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Recommended Prior Activities

- The Vastness of Space

Vocabulary

Term	Part of Speech	Definition
exoplanet	*noun*	planet outside the solar system, orbiting a star other than the sun. Also called an extrasolar planet.

Term	Part of Speech	Definition
orbit	*verb*	to move in a circular pattern around a more massive object.
orbital plane	*noun*	flat space in which a body orbits.
planet	*noun*	large, spherical celestial body that regularly rotates around a star.
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.
velocity	*noun*	measurement of the rate and direction of change in the position of an object.

For Further Exploration

Articles & Profiles

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

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

- NASA Jet Propulsion Laboratory: PlanetQuest

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