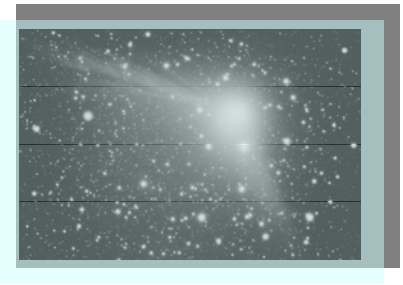
NASA's EPOXI Mission: Eyes on the Skies

Observing Comets

INSTRUCTOR GUIDE



Brief Description: *Eyes on the Skies: Observing Comets* is an activity for educators and high school learners to use while planning and conducting a guided inquiry that involves an observation of a faint comet over time. Learners will consider the comet's physical appearance, such as brightness, and how its physical characteristics change over time.

In this investigation, learners will work with mentors (e.g., teachers, amateur astronomers, informal educators) to observe changes in a comet's appearance over time. During initial observations, learners locate a "faint fuzzy" and chart it. Learners will gain practice star hopping, recording location and brightness observations, and forming questions. How does the apparent brightness of a comet change over time?

Objectives

Learners will:

- Describe NASA's EPOXI Mission
- Describe comets, their place in the Solar System, and what they look like in the night sky

Materials

For each student:

- EPOXI fact sheet
- Activity sheet "Comet Comparisons"
- Observation Log Book
- Star charts
- Binoculars, telescope, or remote access telescopes
- Internet access
- Investigation rubric
- Communicating, Questioning, and Listening text

Procedure

I. The EPOXI Mission: An Inferential Strategy

1. Begin by using an inferential strategy with your learners for reading the EPOXI mission fact sheet. The teacher should:
    a. Analyze the content of the fact sheet for important ideas.
    b. Select three or four ideas that are important and might be difficult to understand. (For this fact sheet, one idea might be what comets are and what they are made of.)
    c. Develop two questions for each idea identified in (b). The first question should be framed on the background knowledge and the second should be a prediction question. (For this fact sheet and idea, a background question might be: "What do you know about comets?" or "Can you describe a time when you saw a comet in the nighttime sky?" A prediction question might be: "If you could send a spacecraft to visit a comet, what would you want to know?"

d. Discuss the responses to both the background and prediction questions **before** the learners read the fact sheet.
e. After the discussion, assign the fact sheet to be read.
f. For follow-up discussion, relate the prediction questions to what actually is being planned for the Deep Impact mission.
g. Evaluate the ideas that motivated the background and prediction questions

II. Comet Perceptions: Assessing Prior Knowledge

The purpose of this activity is for the educator to assess learners' prior knowledge about comets, their place in the Solar System, and what they look like in the night sky BEFORE learners complete comet observations.

1. Ask learners to write down the first thing that comes to their minds when they hear the word "comet." Accept all reasonable answers. Learners might describe an object in the sky that is fuzzy or a fireball that streaks across the sky. Based on the types of responses that you hear, use the information found at http://deepimpact.umd.edu/educ/ExploringComets04.html, "A Comet's Place in the Solar System," to address misconceptions about comets.

Common Comet Misconceptions

- Comets are in the atmosphere (i.e. flash across the sky quickly).
- Comets are the same as meteors.
- Comets are hot balls of fire, or at least the tail is a ball of fire.
- Comets transmit light rather than reflect light.
- Comets consist of a bright tail only. (Many people don't know there is a nucleus.)
- Comets are made of rock and iron.
- Some comets are not in orbits.
- The coma is the same size all the time. (It grows or shrinks according to its proximity to the Sun.)

2. Based on the information described on the "A Comet's Place in the Solar System" Web page, learners are asked to make drawings of comets.

Tip
History of Comet Observations

Learners can read about how comets were observed in the past. Refer them to these Web sites:

http://deepimpact.umd.edu/educ/ExploringComets03.html
"Consider the 'impact' comets have had throughout history."

http://dawn-aop.astro.umd.edu/beginner/sec2.shtml
"What Do They Look Like in the Sky?"

http://deepimpact.jpl.nasa.gov/science/comets-cultures.html
"Comets and Ancient Cultures"

3. Next, ask learners to make observations of two or three images of Comet Hartley 2 located at: http://www.observatorij.org/images/103p-a.html. As they make their observations, learners can draw and list what they observe and what questions they have about the comet's brightness. Learners might notice that images of the same comet look different. Lead learners to an understanding that this is because of its geometric orientation. As learners make drawings you may want them to label the coma and tail. Point out that the nucleus (a focal point of the EPOXI mission) cannot be seen.

4. Ask students what they think the nucleus of Comet Hartley will look like? Allow students to respond. Explain that we won't know until the EPOXI spacecraft arrives."

III. Comet Observations

Learners will now be encouraged to find observable comets in the nighttime sky (if there is one observable). This will provide learners with a contrast between comet photographs studied in the previous section to the "faint fuzzies" of low magnitude comets.

1. Discuss with learners why it is important to make careful observations of objects in the night sky. Ask learners to think about examples of when two people who are observing the same object can make different descriptions.
2. Distribute the Activity Sheet "Comet Comparisons." Professional astronomers also can observe the same object and describe them in different ways. Instruct students to observe the image of Comet Machholz, write a personal description, and read the three descriptions provided by astronomers. Learners should use the Venn diagram to note similarities and differences in the descriptions.

Tip
Observations

Present a common household object for students to observe. Ask each learner to make careful qualitative observations noting as much detail as possible. Once learners have written down some descriptions, ask them to share their descriptions with the class. Note these on the board and indicate observations that are repeated and those that are unique.

Notes

In comparing the descriptions students may note the following.

- Some descriptions include only observations, while some include interpretation too.
- We suggest including observations only, then adding interpretation as a separate step.
- When students are comfortable with the observations and have experience, the interpretation flows as in the case with some experienced astronomers.

- Note in Astronomer 3 above, the phrase gas tail is synonymous with ion/gas/plasma tail.
- An ion is a molecule with a charge, either positive or negative. An ion and plasma are the same thing. Most of the ions in comets are gases in their neutral state, so sometimes the tail is called a gas tail. The dust tail can have gas in it, but not as charged ions, so they behave differently upon leaving the nucleus.

- Why are the measured extents of the coma different as described by Astronomer 2 and 3?
- They defined the boundary of the coma differently. Students should make their own measurements and check for errors of measurement. And understand the difference between measurement error and subjective definitions of boundaries.

3. Depending on your learners' level of experience, provide them with background information (see the Background Information box at the end of this guide) that is most appropriate for observing a faint comet.
4. Learners should have a basic understanding of star charts, major constellations, and how to roughly estimate distances (i.e., one fist at arm's length is about ten degrees, one finger at arm's length is about one degree) before they try finding a comet. It might be useful for learners to try finding bright stars (e.g., Sirius in Canis Major, Rigel and Betelgeuse in Orion, and Aldeberan in Taurus). Once they have had some practice with these, have learners practice finding fainter objects such as the Pleiades and Hyades star clusters near Taurus or the stars Mizar and Alcor in the handle of the Big Dipper.

5. Have learners use the Ephemeris Generator and star charts to locate a comet that is observable. Below we provide an example of how students could use the Ephemeris Generator to find the location of Comet Hartley 2. Once they have practiced this, they can make observations of a visible comet using binoculars or a telescope. Instruct them to record observations in their log book.

Use an Ephemeris Generator to find the right ascension, declination, and magnitude of Comet Hartley 2.

The Solar System Dynamics Groups at the Jet Propulsion Laboratory has an online Solar System data and ephemeris computation service that provides access to highly accurate ephemerides for Solar System objects. An ephemeris table gives the position of celestial objects at different times and from different observing sites. Use the following procedure to find the right ascension and declination of Comet Tempel 1 (also known as 9P/Tempel 1) at the time of impact (0600 4 July 2005 UT).

a. On a computer with Internet access, go to: http://ssd.jpl.nasa.gov/horizons.cgi
b. Click on the button that says "Target Body."
c. Under "change," enter "Hartley 2," then limit to "small bodies only (asteroids and comets) click "Search"
d. Click on "Observer Location."
e. Under "Choose from a list," use the "Choose the state and then Display Cities." Choose the town or city that is closest to your location. Then click on "Use Selected Location."
f. Click change on "Time Span."
g. Enter the start date and time as the local time that you will begin observing.
h. Enter the stop date and time as the end of the same day for a desirable observing time interval (local time).
i. Click on "Use Specified Settings."
j. Click on "Output Quantities and Format."
k. Choose Number 1, "Astrometric RA and DEC," and Number 9, "Visual Magnitude and Surface Brightness," and de-select all other check boxes.
l. Click on "Use Specific Settings."
m. Click on "Generate Ephemeris."

Tip
Log Book

Stress the importance of recording observations into a log book. For more information visit: http://dawn-aop.astro.umd.edu/beginner/sec7.shtml

Sample Log Book:
http://dawn-aop.astro.umd.edu/beginner/observing_log.doc

7. Learners should compare comet images that they can observe through small telescopes or binoculars verses the images found on the Internet. They should note that their observations were probably not as spectacular. Why is this so?
8. Tell learners that as they plan their investigation and make observations in the next section, they should keep accurate observations in their log book. High quality descriptions of what they see from multiple images can be useful to mission scientists.

Tip
Extension
As an extension, learners may observe other images of comets.
http://www.cometography.com/

IV. Planning the Investigation

1. Once learners have been able to consistently locate a comet, they should be ready to make some observations over time and begin their planning. As learners plan, they should begin by writing a question that they think can be answered based on their past and future observations. One such question might be: "How does the comet's brightness change over time?"
2. (Assessment Option) Distribute the investigation rubric to learners and explain that the criteria on the rubric will be used for assessment. Make sure that learners understand each of the criteria and the different levels of performance as described in the rubric. Allow learners to contribute new wording for rubric statements for which they have questions. Also, allow learners to add criteria based upon what is important to the class. (Collect their feedback and redistribute the revised rubric.)
3. Based on the experiences of the learners (observations, question, and prediction), have them develop a plan or procedure for making observations over time. Refer learners to the activity that is outlined at the bottom of http://dawn-aop.astro.umd.edu/intermediate/sec3.shtml for one idea. Learners should base their plan on the available time and resources (availability of equipment) during the observation period. Teachers who are assisting learners with remote access telescopes should provide details for operation and proper protocols. Learners who will not be using remote access telescopes can access images of comet Tempel 1 taken by amateurs and other learners located at http://dawn-aop.astro.umd.edu/gallery/tempel.shtml.
4. Encourage learners to carry out their plans and record observational information in their logs.

V. Conducting the Investigation (optional)

1. Encourage learners to work with local amateur astronomers, science center personnel, or other scientists to refine and conduct their investigation. Stress the importance of keeping good records in their log book.

VI. Communicating Your Findings (optional)

1. Encourage learners who have conducted the investigation to communicate their findings through their choice of venues: Online Journal, Class Journal, Formal Abstract, Research Poster, or Science Fair Project.
2. Have learners read the text, "Communicating, Questioning, and Listening." Explain that this text provides useful information that will help them communicate their findings. Remind learners that they will be assessed with the investigation rubric.
3. Provide time for the learners to present their findings.
4. Conclude this activity by encouraging learners to submit their findings for possible publication on Amateur Observers' Program Web site http://dawn-aop.astro.umd.edu/gallery/logbook.shtml

National Science Education Standards Addressed:

Grades 9–12

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions and concepts that guide scientific investigations

- Design and conduct scientific investigations
- Use technology and mathematics to improve investigations and communications
- Formulate and revise scientific explanations and models using logic and evidence
- Communicate and defend a scientific argument

History and Nature of Science

Historical Perspectives

- In history, diverse cultures have contributed scientific knowledge and technological inventions.

Project 2061 Benchmarks Addressed

Grades 6–8

The Universe

Solar System

- ...chunks of rock mixed with ice having off center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen materials from their surfaces and pushes it into a long illuminated tail.
- Something can be "seen" when light waves emitted or reflected by it enter the eye.

Resources

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: A tool for curriculum reform. Project 2061*. Cary, NC: Oxford University Press.

National Research Council. (1996). *National science education standards*. Washington DC: National Academy Press.

http://antwrp.gsfc.nasa.gov/apod/ap041213.html
Astronomy Picture of the Day Announcing Comet Machholz on 13, December 2004

http://cfa-www.harvard.edu/iau/Ephemerides/Comets/
This Web site provides an up-to-date list of observable comets. The list is maintained by the Minor Planet Center at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts.

http://cfa-www.harvard.edu/icq/icq.html
This is the International Comet Quarterly's (ICQ) Web site. It has a wealth of information about how to observe comets. Interested observers can even subscribe, for a fee, to the International Comet Quarterly publication.

http://cfa-www.harvard.edu/icq/ICQLinks.html
The ICQ also maintains a list of links to other "recommended sites with useful and original comet information."

http://cometography.com/current_comets.html
Gary W. Kronk's Cometography Web site contains histories and summaries of comet observations.

http://science.nasa.gov/headlines/y2005/05jan_machholz.htm?list595414
Green Comet from Comet Machholz from NASA Headlines

http://www.handsonuniverse.org/
From the Lawrence Hall of Science at U.C. Berkeley, the Hands-On Universe™ (HOU) is an educational program that enables students to investigate the Universe while applying tools and concepts from science, math, and technology.

Background Information

- Using a Star Chart http://dawn-aop.astro.umd.edu/beginner/sec4.shtml
- Star Hopping http://dawn-aop.astro.umd.edu/beginner/sec6.shtml
- Using Ephemeris information http://dawn-aop.astro.umd.edu/intermediate/sec1.shtml
- Using Equipment http://dawn-aop.astro.umd.edu/beginner/sec5.shtml
- Recording Observations http://dawn-aop.astro.umd.edu/beginner/sec7.shtml
- Relative Magnitude http://dawn-aop.astro.umd.edu/intermediate/sec3.shtml