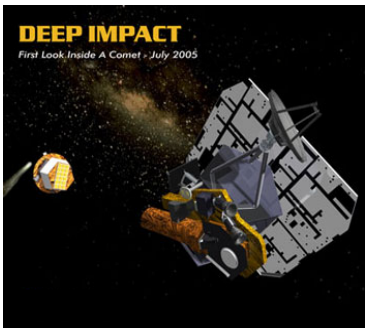

"Deep Impact Comet on a Stick"

Created for the Deep Impact Mission, A NASA Discovery Mission
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Student - Inquiry

Purpose:
Develop a model of a comet and use the same thought processes as a science and engineering team do to design and build missions. Use it to test your theories about comets and then evaluate the strengths and weaknesses of your comet model. The importance of the activity is not the initial model, but the model your students improve or design and their evaluation of the initial model.

Project:
The **Deep Impact** mission will launch in 2004 and encounter Comet Tempel 1 on July 4th of 2005. The **Stardust** mission is in space right now and headed toward Comet Wild (pronounced Vilt) 2. Before these missions launch, scientists and engineers use modeling to research and test some of their theories about comets. They also use modeling to find solutions to some of their mission challenges. Modeling takes place throughout the life of a mission as challenges arise. You can try modeling by making a "Comet on a Stick". Use it to test the influence of the Sun on these small bodies. Discuss as a class some theories about comets. Then try to communicate them with the stick comet. This is a good model for some of the attributes of a comet. For others, it is not. Can you figure out which are the strengths and weaknesses for this model? Can you improve the stick comet model? Can you design your own model to communicate what you know or need to know if you are going to design a mission to a comet? If you need to know more about comets, visit http://deepimpact.jpl.nasa.gov and http://stardust.jpl.nasa.gov to learn more about the Deep Impact Stardust missions.

Before you start:
As a class, discuss what you know about comets. Build one list. Add to that list the things you wonder about comets or don't know. Now you want to build a model to study one question: If you have to send a spacecraft to a comet, what will you need to consider about the way the Sun affects a comet? Now, build your "Comet on a Stick".

Materials:
One 2" styrofoam or other ball
One 5" strip of tape
An electric hairdryer/electrical power available
Two 1 – 2 ft lengths of mylar gift strips
One wooden skewer (shish kabob type)
One marker pen
You or your students gather household or art supplies for students to use to design their own comet models.

Directions:
1. Make a tiny hole in the ball so it can be mounted on the skewer (the fit of the skewer should be tight). Mount the ball on the skewer.
2. Place the mylar strips on top of the ball so the two pieces cross each other in an "X" and the lengths of all sides of the strips hang down evenly. You can also use light ribbon.
3. Attach the strips to the ball with the 5" strip of tape or narrow masking tape wrapped over the strips and around the circumference of the ball.
4. With a marker pen, assign a "front" for your comet and represent it with the letter "H" for head. On the opposite side, mark the letter "T" for tail of the comet.

Here's what you do:

Use a hairdryer to simulate a portion of the Sun's solar energy as it meets the comet. The heat from the Sun causes gas, ice, particles and rocky debris of various sizes to burst from the comet (called coma) and the solar wind causes these substances to form a "tail" behind the comet. Have someone be the "Sun" and stand in place with the hairdryer. The hairdryer simulates the solar wind causing the comet tail (mylar strips) to form and trail behind the comet. Aim the hairdryer at the comet as it approaches and as it moves away. The "Sun" will have to turn in place to keep the "solar wind" flowing to the comet. You hold the comet by the stick and walk in an elliptical orbit around the Sun. As the comet gets closer to the Sun, the solar heating and solar wind affects the comet so that the tail forms and so that it stays in opposition to the Sun. As it travels away, the lost solar heating of the Sun causes the tail to diminish.

Questions: Use the materials you gathered to have students improve or build new models.

1. How does this model succeed in showing the influence of the Sun on a comet?
2. How is this model unsuccessful at showing the proper influence of the Sun?
3. What other elements of a comet can be seen using this model?
4. Which elements of a comet are not well shown by this model?
5. Can you improve the model by changing it or making an entirely new model?
6. The Stardust mission takes a comet sample by flying near the front of Comet Wild 2 instead of the trailing tail. Why? Can you model the reason for their decision?
7. The Deep Impact mission makes a crater in the nucleus of Comet Tempel 1 with a copper projectile. A sister spacecraft nearby takes optical and spectrometer data during the encounter and for 14 minutes after impact. What do they need to consider about a comet in order to successfully gather their data?
8. Form teams and choose three facts about comets you would like to show through modeling. Make a new model or improve your ping-pong comet.
9. As a team decide what kind of comet mission you would design. Take one of the challenges you will face and try to create a model that will help you work the challenge to a solution.

Tips for the Teacher:

1. A hairdryer only sends "wind" from one side while the Sun would be sending out solar wind from all sides.
2. This model does form a tail with the solar wind but it fails to show that the material that outgases from the comet mostly shoots forward. This is why we see the front of the comet glow but do not directly see the nucleus of the comet which is hidden further back inside the comet's coma.
3. The Stardust mission will not take its sample from the tail behind the comet because there is a much higher concentration (density) of material on the sunward side where it originates. By the time it blows back into the tail, it is very spread out. Similarly, the Deep Impact observing spacecraft must maintain a path beneath the comet, which passes overhead. This helps the spacecraft to avoid coma debris from the comet tail and safely transfer its images and other data to Earth through the Deep Space Network antennas.
4. This model does not show that the tail of a comet appears curved because in space we see a "history of the tail". At any point in time, particles move directly away from the Sun (as in this model). Over time, as the comet curves around the Sun on its orbit path, the particles leave a tail that is curved (not shown in this model).
5. As the comet moves away from the Sun, the model tail droops. In space, the particles and debris continue to be swept away from the nucleus, but the production rate of debris decreases.
6. Comets are not white since the rock and debris being outgassed clings to the surface of the comet in a crust that is blacker than toner for a copy machine. Comets also appear in different irregular shapes and are not round "balls". They are shaped more like potatoes. Scientists are not sure how rough or smooth the surface of a comet might be and will get that information from the missions currently planned by NASA.
7. Comets have three tails: the largest is the dust tail produced by radiation light pressure from the Sun. The ion tail, produced by "solar wind" and a neutral sodium tail produced by solar wind.