Name:_____
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15 Building a Comet

15.1 Introduction

Comets represent some of the earliest material left over from the formation of the solar system, and are therefore of great interest to planetary astronomers. They are also beautiful objects to observe in the night sky, unlike their darker and less spectacular cousins, asteroids, and therefore capture the attention of the public. The objective of this lab is to teach you more about these fascinating objects.

- *Goals:* to discuss the composition, components, and types of comets; to build a comet and test its strength and reaction to light
- *Materials:* trash bag, bucket, spoon, towel, mallet, light source, a rock, water, sand, ammonia, corn syrup, dry ice

15.2 Composition and Components of a Comet

Comets are composed of ices (water ice and other kinds of ices), gases (water, carbon dioxide, carbon monoxide, hydrogen, hydroxyl, oxygen, carbon, silicon, and so on), and dust particles. The dust particles are smaller than the particles in cigarette smoke. In general, the model for a comet's composition is that of a "dirty snowball."
Comets have several components that vary greatly in composition, size, and brightness. These components are the following:

- *nucleus*: made of ice and rock, roughly 5-10 km across
- *coma*: the "head" of a comet, a large cloud of gas and dust, roughly 100,000 km in diameter
- *gas tail*: straight and wispy; gas in the coma becomes ionized by sunlight, and gets carried away by the solar wind to form a straight blueish tail. The shape of the gas tail is influenced by the magnetic field in the solar wind. Gas tails are pointed in the direction directly opposite the sun, and can extend 10^8 km.
- *dust tail*: dust is pushed outward by the pressure of sunlight and forms a long, curving tail that has a much more uniform appearance than the gas tail. The dust tail is pointed in the direction directly opposite the comet's direction of motion, and can also extend 10^8 km from the nucleus.

15.3 Types of Comets

Comets originate from two primary locations in the solar system. One class of comets, called the **long-period comets**, have long orbits around the sun with periods of > 200 years. Their orbits are random in shape and inclination, with comets entering the inner solar system from all different directions. These comets are thought to originate in the **Oort cloud**, a spherical cloud of icy bodies that extends from $\sim$ 20,000 – 150,000 AU from the Sun. Some of these objects might experience only one close approach to the Sun and then leave the solar system (and the Sun's gravitational influence) completely.

In contrast, the **short-period comets** have periods less than 200 years, and their orbits are all roughly in the plane of the solar system. Comet Halley has a 76-year period, and therefore is considered a short-period comet. Comets with orbital periods < 100 years do not get much beyond Pluto's orbit at their farthest distance from the Sun. Short-period comets cannot survive many orbits around the Sun before their ices are all melted away. It is thought that these comets originate in the **Kuiper Belt,** a belt of small icy bodies beyond the large gas giant planets and in the plane of the solar system. Kuiper Belt objects have only been definitely confirmed to exist in the last several years.

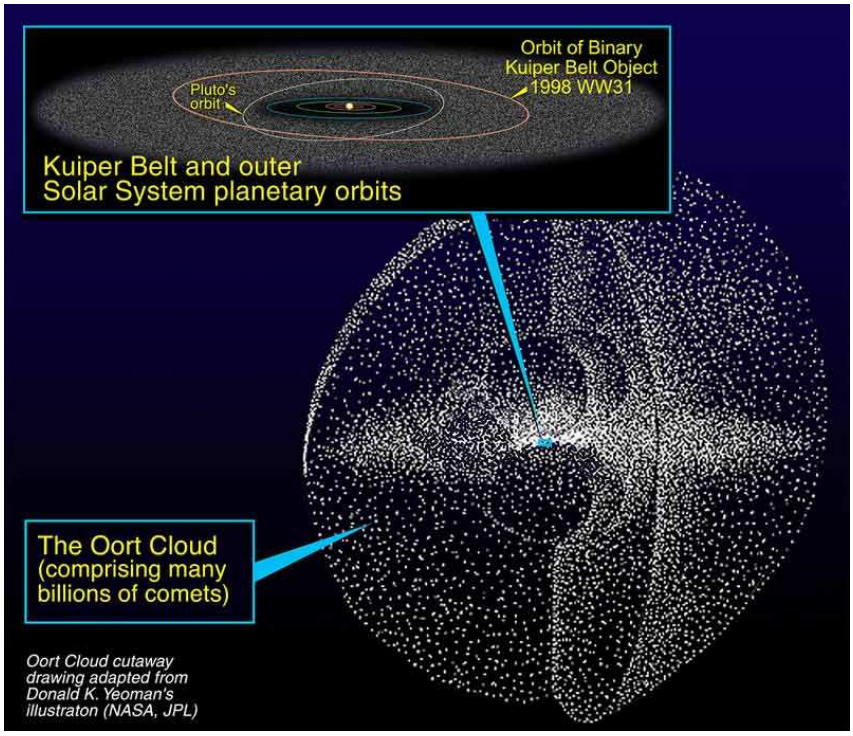

Figure 15.1: Different origins for long and short period comets. Image courtesy of NASA.

15.4 Exercises

15.4.1 Building a Comet

In this portion of the lab, you will actually build a comet out of household materials. These include water, ammonia, corn syrup, and dry ice (CO_2 ice). Be sure to distribute the work evenly among all members of your group. Follow these directions:

1. Cut open a trash bag and use it to line your bucket.
2. Place 1 cup of water in the bucket.
3. Add 2 spoonfuls of sand, stirring well. (**NOTE:** Do not stir so hard that you rip the trash bag lining!!)
4. Add a dash of ammonia.
5. Add a dash of organic material (dark corn syrup). Stir until well-mixed.
6. Place a block or chunk of dry ice inside a towel and crush the block with the mallet.
7. Add 1 cup of crushed dry ice to the bucket, while stirring vigorously. (**NOTE:** Do not stir so hard that you rip the trash bag lining!!)
8. Continue stirring until mixture is almost frozen.
9. Lift the comet out of the bucket using the plastic liner and shape it for a few seconds as if you were building a snowball.
10. Add 1/2 cup water and wait until mixture is frozen.
11. Unwrap the comet once it is frozen enough to hold its shape.

15.4.2 Comets and Light

Observe the comet as it is sitting on a desk. Make note of some of its physical characteristics, for example: (**5 points**)

- shape:
- color:
- smell:

Now bring the comet over to the light source (overhead projector) and place it on top. Observe and record what happens to the comet. (**5 points**)

15.4.3 Comet Strength

Comets, like all objects in the solar system, are held together by their internal strength. If they pass too close to a large body, such as Jupiter, their internal strength is not large enough to compete with the powerful gravity of the massive body. In that case, a comet can be broken apart into smaller pieces. In 1994, we saw evidence of this when Comet Shoemaker-Levy/9 impacted into Jupiter. In 1992, that comet passed very close to Jupiter and was fragmented into pieces. Two years later, more than 21 cometary fragments crashed into Jupiter's atmosphere, creating spectacular (but temporary) "scars" on Jupiter's cloud deck.

After everyone in your group has carefully examined your comet, it is time to say goodbye. Take a sample rock and your comet, go outside, and drop them both on the sidewalk. What happened to each object? (**5 points**)

15.5 Questions

1. Draw a comet and label all of its components. Be sure to indicate the direction the Sun is in, and the comet's direction of motion. (**10 points**)

2. What are some differences between long-period and short-period comets? Does it make sense that they are two distinct classes of objects? Why or why not? (**10 points**)

3. List some properties of the comet you built. In particular, describe its shape, color, smell and weight relative to other common objects (e.g. tennis ball, regular snow ball, etc.). (**10 points**)

4. Describe what happened when you put your comet near the light source. Were there localized regions of activity, or did things happen uniformly to the entire comet? (**5 points**)

5. If a comet is far away from the Sun and then it draws nearer as it orbits the Sun, what would you expect to happen? (**10 points**)

6. Do you think comets ("dirty snowballs") have more or less internal strength than asteroids, which are composed primarily of rock? [Hint: If you are playing outside with your friends in a snow storm, would you rather be hit with a snowball or a rock?] (**10 points**)

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15.6 Take-Home Summary

Summarize the important ideas covered in this lab. Questions you may want to consider are:

- Why are comets important to planetary astronomers?
- What can they tell us about the solar system?
- What are some components of comets and how are they affected by the Sun?
- How are comets different from asteroids?

Type this summary. Use complete sentences, and proofread your summary before handing in the lab. **(30 points)**

15.7 Extra Credit

Use the internet to look up one (or more) of the following current or planned spacecraft missions to comets and briefly describe the mission, its scientific objectives, and the significance of these objectives. **DO NOT copy the information from the web sites; put it into your own words! (3 points each)**

- Stardust (`http://stardust.jpl.nasa.gov/`)
- Deep Impact (`http://deepimpact.umd.edu/home/index.html`)
- Rosetta (`http://sci.esa.int/science-e/www/area/index.cfm?fareaid=13`)
- CONTOUR (`http://discovery.nasa.gov/contour.html`)