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Monster Comet Promises Big Show

The awsome spectacle of a brilliant comet, with its long ghostly tail streaming behind it, is a rare event. Usually one appears about once a decade. This past March, many people thrilled to Comet Hyakutake, which passed within a mere 0.1 astronomical units of Earth (15 million kilometers, 9.5 million miles) and became a stunning sight for several nights. But nature is favoring us again: Another potentially great comet, Comet Hale-Bopp, is poised to enter our night sky in early 1997.

Creature of the night. Late in the evening of Jan. 30, 1996 in Japan's Kyushu region, Yuji Hyakutake left his home in Kagoshima and drove to an observing site far from city lights. There, in the sky above him, was a new comet soon to bear his name. Comet Hyakutake became the most active comet in the past 400 years to come so close to Earth. Photo courtesy of Carter Roberts of Berkeley, Calif. © 1996 Carter Roberts.

Comet Hale-Bopp stands to be among the most intensely studied comets in history. Only one other comet, Comet Halley, was seen so far from the Sun, giving scientists an opportunity to watch it as it slowly warmed up and sprouted a tail. Hale-Bopp appears to be much larger than Halley: about 40 kilometers (25 miles) in diameter, four times the width of Halley. And since Halley's appearance in 1986, scientists have developed new techniques and instruments, not least the Hubble Space Telescope, to scrutinize comets.

Comets are the Rip Van Winkles of the solar system -- mini-worlds that have changed little during their 4.5-billion-year nap far from the Sun. By reading their tales of the distant past, scientists learn about how our solar system came to be. At the same time, comets provide science educators a visual treat to entice their students and the general public.

Ancient History

By studying objects such as comets, astronomers have pieced together the story of the creation of the solar system. A little over 4.5 billion years ago, deep in interstellar space, a cloud of gas and dust began to collapse upon itself. As it contracted under its own weight, it started to spin. Some of the material in the cloud settled onto a large central object, and some of it landed on the rotating disc that surrounded that central object. As time went on, so much material landed on the central object that it became hot enough to ignite nuclear fusion. A star, our Sun, was born.

Out in the disc, the material was creating not a star, but things a bit more prosaic: giant dust balls. The dust grains and other materials from the cloud collided and clumped together. Over a few tens to hundreds of millions of years, the clumps began to form small objects, a few miles across, called planetesimals. Over further tens to hundreds of millions of years, these planetesimals collided with each other and stuck together to form still-larger objects. Eventually, the planets arose.

Most of the planetesimals were used up in building the planets, but a few were left over. They are still around today in more or less their original form. Some of these leftover planetesimals are composed of rock and metal: the asteroids. Others consist of easily vaporized materials such as water, carbon monoxide, and other gases in a frozen state: the comets.

Once, comets inhabited the entire solar system. But those near the Sun quickly evaporated into nothingness. Only those that orbited the Sun in the cold, distant reaches of the solar system remained intact. Many of these continue to orbit the Sun in a huge disc -- a remnant of the original planet-forming disc -- beyond Neptune and Pluto: the Kuiper Belt. At its far end, this disc fans out into the Oort Cloud, an enormous sphere of comets which enshrouds the solar system 10,000 astronomical units from the Sun -- a significant fraction of the distance to the nearest star.

Most of those comets remain happily exiled in frigid seclusion. But some are thrust into the realm of the planets. The Sun and the other bodies of the solar system travel through the Galaxy as a unit. Occasionally the solar system passes so close to other stars that it feels their gravity. These gravitational interactions kick some of the comets from the Oort Cloud or Kuiper Belt into the inner solar system.

As these comets make their first swing past the Sun, various planets may yank them into new orbits. Some comets are unceremoniously ejected from the solar system altogether, while others are pulled into short-period orbits of a few thousand, or a few hundred, years. Eventually, some of these are pulled -- usually by Jupiter, the most massive planet -- into very short-period orbits, usually 6 to 8 years long. As these comets slowly evaporate away, others from the outer solar system come in to take their place.


June 17, 1996


July 15, 1996


August 12, 1996

All hail Hale-Bopp. Conrad Jung of Oakland, Calif. took these photos from Fremont Peak in northern California. He used an 800 mm telephoto lens, Fujicolor Super G 800 film, and a 30-minute exposure at f/5.6. In the July photo, the bunch of stars to the right of the comet is the star cluster NGC 6649. Photos courtesy of Conrad Jung.

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Hard-Hat Zone

Planet-building is like a giant snowball fight. The loser of the fight -- the body that gets pummeled the worst -- is the winner: It becomes the largest planet. Nowadays, the snowball fight is much less intense than it was during the turbulent youth of the solar system. But it is not over yet. The planets are still growing slowly as comets and meteoroids collide with them. Events such as the 1994 impact of Comet Shoemaker-Levy 9 into Jupiter remind us that the Under Construction signs in our solar system can't be taken down just yet. The snowball-fight metaphor is especially apt when you consider what comets actually are. In the 1950s, American astronomer Fred Whipple suggested that comets are dirty snowballs: clumps of ice mixed with interplanetary dust. His hypothesis was verified in 1986 when the European Space Agency's Giotto spacecraft flew within a few hundred kilometers of Halley's comet and took photographs of the actual dirty snowball, 15 kilometers (9 miles) long by 8 kilometers (5 miles) across.

For most of its orbit, a comet remains far from the Sun, little more than the dirty snowball that it is -- what is usually called a bare nucleus. Its glory days begin when the nucleus approaches the Sun and starts to feel the heat. Gases and dust start erupting in geysers reminiscent of Old Faithful at Yellowstone National Park. The gas and dust form a large cloud, called the coma, around the nucleus. This coma is what gives comets their fuzzy appearance. If the comet gets close enough to the Sun, radiation pressure from sunlight pushes some of the dust away from the Sun, creating a long tail of dust. The solar wind, a stream of charged subatomic particles from the Sun's surface, blows gas from the coma into a separate tail, known as either the ion, gas, or plasma tail.

These processes are most active when a comet is closest to the Sun, near what is called the perihelion -- Latin for "near Sun" -- point of its orbit. As the comet swooshes around the Sun and begins to recede, its activity decreases. The geysers blow their last gust; the coma disperses into space; and the comet is once again a bare, unloved, dirty snowball, until such time as it approaches the Sun on its next go-around.

Astronomers know of over 1,000 snowballs that have made the journey at least once. Most of these have been discovered this century, when astronomers started looking for them with powerful telescopes, which reveal much dimmer comets. Some 120 comets have been observed at two or more returns. Each year, observers discover a dozen or so new comets; in addition, a dozen or more comets that are already known make their passages around the Sun.

Most of these objects are extremely dim. Perhaps one-third to one-half are visible in the telescopes used by amateur astronomers, but the majority of these are dim, unimpressive objects -- no more than a faint fuzzball. Perhaps three to five comets each year are bright enough to be picked up in a pair of binoculars; of these, perhaps one will reach the point where sharp-eyed observers at dark sites are able to see it with their naked eyes. The truly great comets, those easily visible to the naked eye of anyone who looks skyward, usually occur only once in a decade.

Stars with trains of fire. For King Harold and the Saxons, the appearance of a comet in 1066 was a portent of doom; for Duke William and the Normans, the same comet was a blessing from heaven. Later that year, William's army defeated Harold's forces at the Battle of Hastings. William's wife, Queen Matilda, commissioned this tapestry, the famous Bayeux Tapestry, to commemorate her husband's victory. Today we know that the comet was Halley's comet on one of its recurring visits.

The Discovery of Hale-Bopp

Astronomers have a long-standing tradition: If a person discovers a new comet, he or she is rewarded by having his or her name attached to it. Because of this opportunity for fame, for over two centuries dedicated amateur astronomers have swept the skies, hoping to come across one of these dim fuzzy objects. Today, as part of the efforts to track down objects that could hit Earth, several professional astronomers have gotten into the act as well. Numerous other astronomers, both amateur and professional, observe known comets on a regular basis and examine everything about them: brightness, physical structure, gas emissions, and so on.

For over 25 years, I have been part of the latter group. So far, I have observed over 200 of these fuzzy visitors. On an average night, two or three comets are visible through the moderately large telescope that I own, and on a semi-regular basis I observe any that are visible. I have also spent time trying to discover a comet of my own, but after years without any success, I gave this up a few years ago.

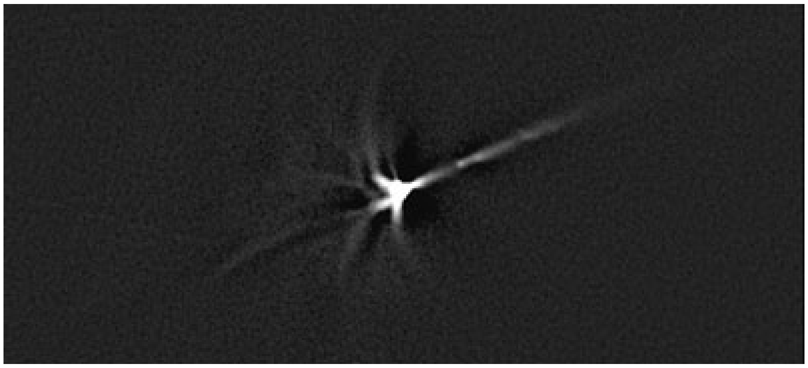
On Saturday night, July 22-23, 1995, I planned to observe the two comets that were then visible in the night sky. After finishing with the first one about midnight, I had an hour to wait before the second comet rose above my house. Because the night was especially beautiful, with the summer Milky Way arching brightly overhead, I decided to pass the time by observing a few star clusters and gas clouds toward the center of the Galaxy.

When I turned my telescope toward one such star cluster, catalogued as M70, I immediately noticed a dim, smaller object in the same field of view. A check of my star atlases, and of the various catalogs of clusters and clouds, revealed that nothing should be in that position. Then I checked the known comets; none were in that location either. After about an hour, I saw that the fuzzy object had shifted its position relative to the background stars -- a sure sign it was a comet.

At once, I reported my find to the Central Bureau for Astronomical Telegrams in Cambridge, Mass., the clearinghouse for reporting and announcing discoveries of comets and other such objects. An amateur astronomer in Arizona, Thomas Bopp, happened to be looking at M70 at about the same time. He, too, noticed the comet, and duly reported it. In keeping with the tradition, the comet was named after the two of us: Comet Hale-Bopp. After all the years I had spent hunting for new comets, and failing to find any, I found one after I had given up the search.

Both Bopp and I had every reason to believe that our comet would be like 99 percent of all the other comets that are discovered: a relatively dim object that would fade from view a couple of months later. But then we saw the first orbital calculations. These calculations, performed by the Minor Planet Center in Cambridge, Mass., applied Newton's law of gravitation in order to translate our position measurements into a distance.

Comet Hale-Bopp was an almost unprecedented 7 astronomical units (1,060 million kilometers, 665 million miles) from the Sun -- halfway between the orbits of Jupiter and Saturn. At this distance, very few comets are visible with any telescope in the world, let alone with a relatively small instrument.



When you're a jet you're a jet all the way. As Comet Hyakutake approached the Sun, jets of dust erupted from the Sun-facing side of its nucleus. Paul Boltwood took this unusually close-in image of the inner coma of the comet using a 7-inch refractor and a homemade CCD camera. The faint streaks in the image are stars. His movie and other educational materials are available on video tape and CD-ROM from Cyanogen Productions at 1-800-835-6794 or ceravolo@fox.nstn.ca.

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Bright Becomes Brighter

The orbital calculations also revealed that the comet was due to pass much closer to the Sun. Its perihelion would occur on April 1, 1997, at which point the comet would be only 0.92 astronomical units from the Sun, just within the orbit of Earth. Because a comet brightens as it approaches the Sun, Hale-Bopp would only become more visible. It might become one of the brightest comets of the past century, if not the past millennium.

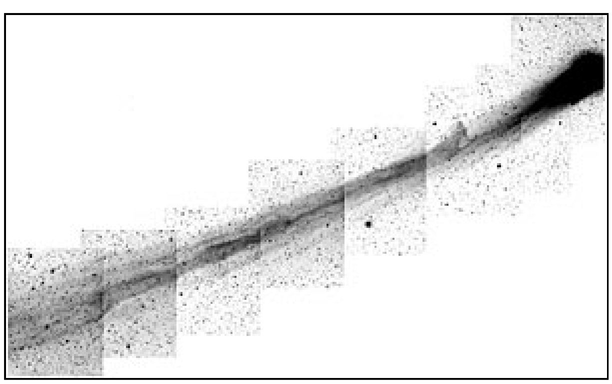
Initially, astronomers cautioned that Comet Hale-Bopp might be experiencing an outburst -- a rapid but temporary upsurge in brightness -- and that it would soon fade to a more typical brightness level. Such outbursts have occasionally been observed in other comets. But soon after the July 1995 discovery, Rob McNaught at the Siding Spring Observatory in New South Wales, Australia went back through the observatory records and found a previously unrecognized image of Hale-Bopp. Taken in April 1993, the photo showed the comet over 13 astronomical units from the Sun, well beyond the orbit of Saturn. This meant that Hale-Bopp was inherently bright.

Since its discovery, Comet Hale-Bopp has brightened more or less on schedule. By mid-1996, sharp-eyed observers in dark sites could find it with their naked eyes, despite its being over 4 astronomical units from the Sun. As of press time in early October, it has already developed a prominent dust tail; detailed photographs have seen eruptions of dust and gas at a phenomenal rate. The signs look good for an impressive display in early 1997 (see box). A year from now, it will be gone, not to return again for 3,400 years.

Hale-Bopp is a scientific windfall, one of only two comets -- the other being Halley -- to be seen as it develops through a wide range of temperatures. Astronomical textbooks had to be rewritten after the 1986 appearance of Halley, and they may well need to be rewritten after the 1997 appearance of Hale-Bopp.

It is also an educational windfall, a chance for students of all ages to participate in gathering knowledge about this visitor. The comet will not shoot across the sky like a meteor; it will gradually shift in position and appearance from night to night. Careful observation of the comet should reveal week-to-week, even night-to-night, variations in its brightness, in the length and structure of its tails, and in the structure of its coma.

Students can record such changes photographically. An ordinary 35 mm SLR camera on a tripod, with a regular, wide-open lens (say, 50 mm at f/1.8) and fast film (ASA 400 or 1000), should be able to record detail in the tail. Comet photographers should experiment with various exposure times to see how the detail varies.



Falling apart. On March 24, 1996, three small pieces of Comet Hyakutake broke off and started to form their own tails, as hinted at in the third frame from the right. This mosaic of negative images (in which dark represents bright) shows both tails of the comet. The twisted strands toward the left are the dust tail. The gas tail is the dark spike at the back of the head of the comet; vaguely flowing from that spike is the straight, narrow continuation of the gas tail. Image and interpretation courtesy of James M. De Buizer and James T. Radomski. © 1996 James M. De Buizer, James T. Radomski, and the University of Florida.

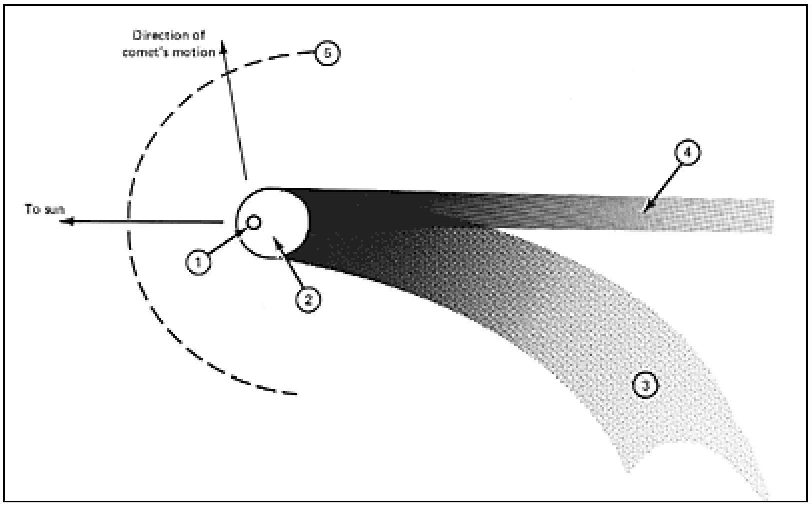
New Age of Science?

Systematic observations make for a deeper appreciation of the beauty of the comet. Students can see for themselves that comets are natural processes, not omens of doom or warnings of divine retribution. Sad to say, such beliefs persist even today. Already I have seen articles that seize upon Hale-Bopp's appearance and the end of the second millennium, and try to attach apocalyptic significance to this. Other articles have claimed that Hale-Bopp is an alien mother ship or has undergone mysterious course corrections that put it on a collision course with Earth.

Ironically, these claims obscure the true, subtle kinship of Hale-Bopp and us. Comets formed when our planet formed. They are made of the same water and organic materials we are. They delivered many of those materials to the early Earth and occasionally revisited to wipe the evolutionary slate clean. By turning the attention of the average layperson skyward for a while, Hale-Bopp may make people feel a little bit closer to the universe of which we are all a part.

As for me, I plan to enjoy the spectacle and to take full advantage of it for the purpose of public science education. I want to do my part to ensure that every person is aware of this comet and has the opportunity to view it. I encourage anyone who shares these goals to work with me toward making them a reality.

ALAN HALE is the founder and director of the Southwest Institute for Space Research in Cloudcroft, N.M. The institute is an independent organization devoted to astronomical research and education. Hale, as in Comet Hale-Bopp, has written a book, *Everybody's Comet* (available through the ASP Catalog) and coordinated an Internet project, "Hale-Bopp: Live in the American Classroom." His email address is ahale@nmsu.edu. For more information on Comet Hale-Bopp, visit http://www.halebopp.com. George Musser contributed to this article.



Anatomy of a comet. The nucleus (1) is the heart of the comet -- a fluffy, dirty snowball 1 to 50 kilometers in diameter. Generally we don't see the nucleus; it is too small. Instead, we see the dust and gas that the nucleus spews off. This material forms the coma (2), a cloud up to 1 million kilometers across which we see as the fuzzy head of the comet. Electrically charged gas from the coma forms the straight tail (4); glowing molecules give it a bluish tinge. Dust (tiny grains of rock) from the coma forms the second, curved tail; reflected sunlight colors it yellowish-white. Diagram courtesy of NASA, based on sketch by Donald. K. Yeomans.

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Observing Comets

James C. White II
Middle Tennessee State University

This past spring, as Comet Hyakutake decorated our evening skies, I received a telephone call from an upset parent. "We bought our daughter a telescope to see the comet," she said, "and we can't see anything!" The exasperated mother said they found binocular and naked-eye views to be better than those through the telescope. "What are we doing wrong?" she asked.

Absolutely nothing! For novice telescope users, comets through the eyepiece disappear. They are pretty faint objects. They may be bright overall, but all that light is coming from a big area of space. Even out in the suburbs, the contrast between the diffuse cometary glow and the not-so-dark night sky can be lost. A telescope, by gathering light from only a small patch of the sky, often just makes it worse.

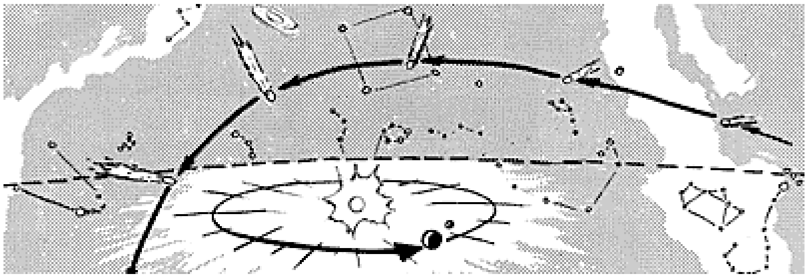
Naked-eye comet-watching is the easiest and most satisfying way to begin, particularly in a rural area. Find yourself the darkest location possible, set up the chaise lounge, break out the hot chocolate, and look up. Binoculars are a nice addition; they allow you to gather a bit more light, while still providing a wide field of view. I recommend binoculars with at least a 7-degree field of view. In suburban and urban areas, the binoculars are crucial. You need that extra light-gathering ability.

OK, you say, I found Comet Hale-Bopp this evening. What next? Comets are not big fireballs that sprint across the heavens; theirs are leisurely strolls. Because they constantly change as they ramble about our skies, comets provide us with an opportunity to observe astrophysical phenomena on short time scales. As you observe Hale-Bopp or any other comet, consider the following:

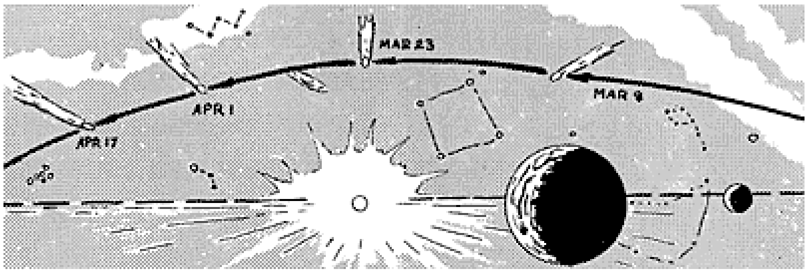
- Does the comet have a tail? If so, has its appearance -- color, length, width -- changed since your last observation?
- Can you see two tails (dust and plasma)? If so, are there color or shape differences between the tails?
- Has the shape or color of the coma changed?
- How does the brightness of the comet compare to nearby deep-sky objects? This is a way to see whether the brightness has changed.

If you have access to a telescope, try to use it as well, but keep the power low. The telescope will enable you to study subtle structural changes in the comet's tail(s) and coma, but it's not necessary.

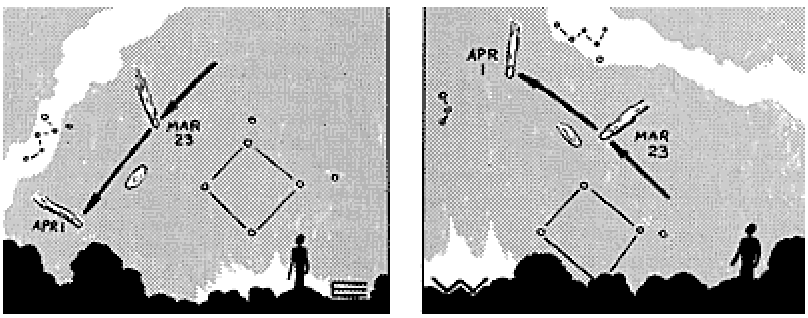
JAMES C. WHITE II is a professor in the Department of Physics and Astronomy at Middle Tennessee State University in Murfreesboro. This article is adapted from his "Guest Observer" column in the November/December 1996 issue of Mercury magazine. In each issue of Mercury, White's column describes an observing project and explains how you can prepare and send us a report of your observations. We select one of these reports for publication in an upcoming issue of the magazine.



Comet Hale-Bopp will pass through the inner solar system during March and April 1997. As it makes its closest approach to Earth, the comet will pass far to the north, above the plane of the solar system -- almost directly above the Sun.



During the spring, the comet will pass through the northern constellations: between the Great Square of Pegasus and Cassiopeia (which is shaped like a 'W' or a '3'). Hale-Bopp passes nearest the Earth on March 23 and nearest the Sun at perihelion on April 1. As the comet passes the Sun, its gaseous tail will be blown backward by the solar wind.



Those in the temperate latitudes of the Northern Hemisphere will have the best view of Hale-Bopp. In late March and early April, the comet will appear in the early morning before dawn, about the width of a hand above the northeast horizon. In the early evening after dusk, look a handspan above the northwest horizon. As the comet moves between Cassiopeia and Pegasus, it will pass very near M31, the spiral galaxy in Andromeda. You'll need a good pair of binoculars to see M31, but Hale-Bopp should be easy to spot with the naked eye.

JAY RYAN is the author of "Starman", an astronomical comic strip featured in the newsletters of over 120 astronomy clubs. "Starman" is also available at http://www.cyberdrive.net/~starman.

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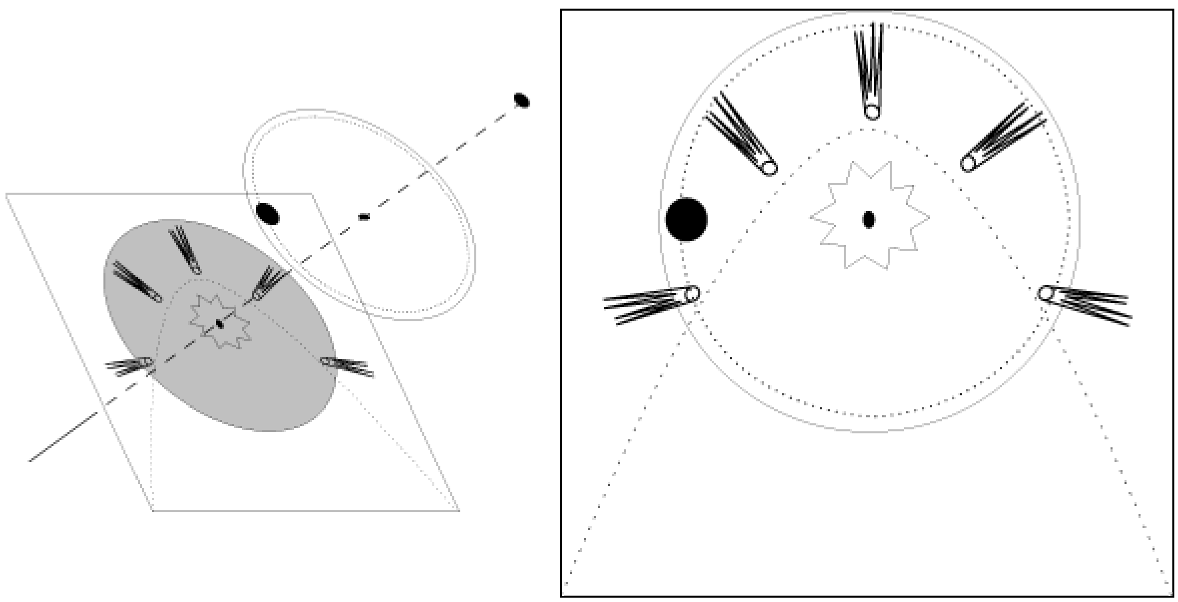
Classroom Activity: A Viewgraph Comet

Julieta Fierro
Universidad Nacional Autónoma de México

Using a very simple viewgraph simulator, teachers can explain why comets take different shapes.



Materials:

1. Two transparencies
2. Colored pens and drawing materials
3. A thick needle
4. A snap or round-headed fastener

Construction:

1. Draw a 10-centimeter (4-inch) diameter circle on one of the transparencies. This will simulate the Earth's orbit around the Sun. Somewhere on the orbit, draw a colored circle about 1 centimeter (half-inch) in diameter; this will represent Earth. Draw the Sun at the center of the orbit. Cut the transparency about a centimeter outside the Earth's orbit. You should now have a circular piece of transparency, which you will later spin to represent the Earth's yearly motion.
2. On the second transparency, draw a section of the comet's orbit. This should look like an arc of an elongated ellipse (see photo). Mark the Sun's position. Draw several comets along the path with their tails pointing away from the Sun. The tails should be smaller when the comet is farther out. In

preparing the viewgraph, you may want to draw first on ordinary paper and later trace it onto the transparency.
3. Heat the point of the needle about 5 seconds on a stove. Poke a hole through both transparencies at the center of the Sun.
4. Place the Earth's orbit transparency on top of the comet one. Fasten them with the snap. You should be able to spin the Earth and change its position relative to the comet.

You can create other viewgraphs that have a smaller scale and show several comet orbits or constellations. Pupils can construct their own comet simulator. They can use cardboard instead of a transparency for the comet's path.

Use:

1. Show how the Earth's orbit is almost circular compared to the comet's. Explain that the Sun is at the focus of the orbits of the planets, asteroids, and comets. Comet orbits are highly elongated; this takes them far from the Sun. In fact, the elongated orbit is why astronomers believe comets originally came from the outer reaches of the solar system.
2. Explain that the comet's tail always points away from the Sun and grows as it approaches it. The tail on the viewgraphs is to scale: Comet tails really do stretch tens or even hundreds of millions of kilometers. Actually, comets have two tails. One, made of hot gas, point directly away from the Sun -- pushed back by the force of the particles that stream outward from the Sun. The other tail, made of dust left behind in the cometary orbit, is short and curved.
3. Turn Earth to different positions and investigate how comets look from several vantage points. We can see a comet head-on (its tail will look short) or on its side (the tail will look long).
4. Explain that sometimes we cannot see the comet, because it is behind the Sun. In January and February, Comet Hale-Bopp will be very close to the Sun from our vantage point.
5. Explain that the tail changes size and that Earth can go through the tail.
6. Be sure to explain that the orbit on the viewgraph is a projection. All bodies orbit in a plane, but a comet does not necessarily orbit in same plane as Earth does.

JULIETA FIERRO is in charge of astronomy popularization efforts at the Instituto de Astronomía of the Universidad Nacional Autónoma de México in Mexico City. One of her many projects has been to work with homeless children in Mexico City -- the subject of an upcoming article in Mercury magazine. Her email address is julieta@astroscu.unam.mx.

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Astrophotography for Teachers and Students

Herman M. Heyn

Photographing astronomical objects and events is not solely the province of professional astronomers wielding giant telescopes. Many of the beautiful photos in astronomy textbooks were taken by amateur astronomers using everyday camera equipment. With Comet Hale-Bopp fast approaching, now is a perfect time to learn the not-too-difficult science and art of still-camera astrophotography. Nine pieces of equipment are needed:

1. A 35 mm single lens reflex (SLR) camera is ideal. Its shutter speed control must have a 'B' or 'T' setting for time exposure; the camera must operate mechanically (not by battery) at that setting. The Pentax K-1000 is one such camera.
2. The best all-around still camera lens has a 50 mm focal length and a speed of f/2 or faster.
3. A reasonably steady tripod is required. Be sure it can tilt the camera toward the zenith (straight up).
4. Depressing the shutter button with your finger introduces ruinous vibrations during time exposures. Use a cable release attachment, the type with a locking collar that locks with one hand.
5. To ensure against jitters as the camera shutter opens and closes, use a piece of black posterboard as the final shutter.
6. You can count off seconds, but more practical is a timing device. A battery-powered metronome ticking once per second is very handy in the dark.
7. A dim, red LED flashlight, or a white one with red tissue paper taped over it, will preserve your night vision while reading star maps, camera settings, or notes.
8. Always keep records of your astrophoto efforts. Data should include date, location, sky conditions, camera and lens specs, film type, and the time, subject, and length of each exposure. A 14-inch clipboard can hold your record sheet.
9. Last is the 35 mm film. Start with ISO 400 slide film. Slides show exactly what you photographed. Once you know what to expect, you can try print film, as well as faster films. Among the latter are Kodak Gold 1000 and Ektachrome P1600 and Fujicolor Super G Plus 800.

Now that you have the required equipment (see photo), you are ready to take astrophotographs. Pick a site as far as possible from urban light pollution and a night without a bright Moon. Then follow these five steps:

1. Load the film and snap a daylight scene for reference purposes. Remove any filters, as they can cause internal reflections in night photography.
2. At the site, mount the camera on the tripod, attach the cable release, set the shutter speed to 'B' or 'T', focus on infinity, and open the lens to its fastest (widest) setting. Organize your timer, clipboard, and red flashlight.
3. Aim your camera at a constellation and frame it as nicely as you can. Recheck the focus and aperture, and cock the shutter. Start your metronome at one tick per second.
4. Holding the black posterboard in front of the camera, depress the cable release button to open the shutter, and lock the cable.
5. On the count of "one thousand zero," move the posterboard away from the camera to begin the exposure. Continue counting: "One thousand one, one thousand two..." At about "one thousand 17" (17

seconds), return the posterboard to the front of the camera and unlock the cable release to close the shutter. Wind the film. Congratulations, you have just taken your first astrophoto!

If your school has a planetarium, you can practice astrophotography in it. Just remember that because the dome is not at infinity, the camera must be refocused for each shot.

In the table below is a list of photogenic evening constellations and recommended exposure times (in seconds) for a 50 mm lens. Note that the farther above or below the celestial equator you point, the longer you can expose before stars leave visible trails. To determine the maximum exposure time without trailing, use the formula: 850/focal length x cosine declination.

Sometimes, star-trailing is desired. The two best constellations for such photos are Orion and Ursa Major. With ISO 400 film and the lens closed to f/4 to avoid overexposing the sky, try a 10-minute exposure. The ultimate, classic star-trails photo is one of an hour or longer centered on Polaris. Close the lens to f/5.6.

Meteors are another possibility. There are about eight "shooting stars" per hour every night, but your chances improve considerably during major meteor showers, such as the Perseids and Geminids. The Perseids peak the evening of Aug. 11 and the Geminids the evening of Dec. 13. Use fast film with the lens wide open. Aim anywhere in the sky and take consecutive 5-minute exposures.

And then there is Hale-Bopp, which, if it lives up to its billing, will be the best comet in decades. From mid-January to mid-March, the comet will be in the predawn sky, and from then until early May, it will be in the post-sunset sky. Use ISO 800 and faster film. With the lens wide open, shoot from 15 to 35 seconds in 5-second increments. For perspective, put trees, buildings, and even people in your foreground.

One last astrophotography suggestion: the near-total lunar eclipse of March 24. With a 50 mm lens, the Moon's image is quite small; a 135 mm or longer focal length is better. Use ISO 200 film and bracket your exposures -- that is, try several camera settings for each stage of the eclipse. While the Moon is full, use 1/400 seconds at f/16, f/11, and f/8. As the shadowed area grows, use progressively wider stops, such as f/11, f/8, and f/5.6. As the umbra enlarges, use f/11, f/8, and f/5.6. At mid-eclipse, when only a sliver of the Moon remains, open to f/4 and bracket from 1/15 to 2 seconds.

Astrophotography is within your reach. Give it a try!

Winter	Spring	Summer	Fall
Orion (17)	Leo (18)	Hercules (21)	Cassiopeia (34)
Taurus-Pleiades (18)	Ursa Major (34)	Scorpius (19)	Triangulum (21)
Canis Major (18)	Ursa Minor (50)	Sagittarius (20)	Andromeda (22)
Perseus (24)	Boötes (18)	Lyra (21)	Cepheus (50)
Auriga (22)	Corona Borealis (20)	Cygnus (22)	Pegasus (18)
Gemini (19)	Corvus (18)	Delphinus (18)	Aries (18)
Cassiopeia (34)	Coma Berenices (19)	Aquila (17)	Double Cluster (30)

HERMAN M. HEYN is a long-time amateur astronomy and astrophotographer living in Baltimore. He is on the staff of the Maryland Space Grant Consortium. Many of his astrophotos have appeared in Sky & Telescope magazine and in astronomy books. Heyn can often be found loitering on street corners in downtown Baltimore at night -- along with his Meade 8-inch Schmidt-Cassegrain telescope, which he encourages passers-by to look through. He welcomes readers' reports on their astrophoto efforts. His mailing address is 721 E. 36th St., Baltimore, Md. 21218; phone: (410) 889-0460.

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Andrew Fraknoi
Foothill College

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Hale-Bopp on the World Wide Web

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ANDREW FRAKNOI is the chair of the astronomy department at Foothill College in Los Alto Hills, Calif. He is the director of the ASP's Project ASTRO and lead author of a new astronomy textbook, Voyages Through the Universe, published by Saunders. He tells us that his son Alex, now 3, knew the words "planet," "star," and "Moon" by age 2.