Reflections

of the University Lowbrow Astronomers

February 1997

Comet Holmes (right center) passing by M31. Photo from the Lick Observatory, November 21, 1892.

The University Lowbrow Astronomers

is a club of Astronomy enthusiasts which meets on the third Friday of each month in the University of Michigan's Physics and Astronomy building (Dennison Hall, room 807). Meetings begin at 7:30 PM and are open to the public. Public star parties are held twice each month, weather permitting, at the University's Peach Mountain Observatory on North Territorial Road (1.1 miles west of Dexter-Pinckney Road; see inside for directions) on the Saturday evenings before and after the new Moon. For more information call (313) 480-4514.

Important Dates

This Month:

Feb 1 - **Public Open House** at Peach Mountain Observatory

Feb 8 - **Public Open House** at Peach Mountain Observatory

Feb 21 - **Meeting** at 807 Dennison Tonight's topic: *Everything You Always Wanted to Know About Comets (but were afraid to ask)*

Feb 16 - **ATM Subgroup** will meet at 2 pm at Tom Ryan's House Call Tom at (313) 662-4188 for directions

Next Month and Beyond:

Mar 1 - Southern Michigan Amateur Astronomers Convention at Easterm Michigan University. Call 487-3033 for info.

Mar 8 - **Open House** at Peach Mountain Observatory

Mar 15 - **Open House** at Peach Mountain Observatory

Mar 21 - **Meeting** at 807 Dennison Topic TBA

Apr 5 & 12 - **Open House** at Peach Mountain Observatory

Remember: April 12 is Astronomy Day!

Pre-SL9 Comet Crash on Jupiter ?

The discovery of an old drawing of a possible impact spot on Jupiter, recorded in 1690

Dr. Junichi Watanabe
<watanabe@pub.mtk.nao.ac.jp>
National Astronomical Obs. Japan

Are there any cases where astronomers witnessed impact spot on Jupiter (like those produced by the fragments of comet Shoemaker-Levy) in the pre-photographic era? After the comet D/ Shoemaker-Levy 9 crashed on Jupiter in 1994, many historical records from the period 1600-1900 have been examined by several astronomers. While some candidates of possible impact origin have been noticed, "the descriptions and drawings lack the detail required to meet the necessary condition" (T. A. Hockey, 1996, in *Planet. Space Sci.*, Vol.44, No.6, p. 559). However, it is important to continue our effort to discover such records.

A Japanese amateur astronomer, Isshi Tabe <tabe@yk.rim.or.jp>, who is studying historical records of Jovian atmospheric phenomena, tried to find out undiscovered drawings preserved deeply in libraries. When he found a drawing in the library of Paris Observatory, France, he was very excited because it supplied the "detail required to meet the necessary condition for impact spot". Namely, it contains the time variation of the dark spot during 18 days. Ms. Michiwo Jimbo, who is also an amateur astronomer, translated old French in the drawing to Japanese. Dr. Junichi Watanabe, who had organized Japanese SL-9 impact observations at the Okayama Astrophysical Observatory, joined to analyze the characteristics of the drawing.

This was drawn by famous astronomer Giovanni-Dominique Cassini (1625-1712), who was one of the most reliable, excellent visual observers. Detailed description of this observed spot appeared in a text of "Nouvelles des couvertes dans le globe de Jupiter" which is in the Library of the Paris Observatory. In this drawing, he recorded time variation of a dark spot, which appeared on December 5, through December 23, 1690.

Several characteristics of this spot are similar to those of impact spots of the SL-9:

- This spot appeared abruptly as a round, dark spot on December 5. "The spot is truly round and its diameter is 1/20 of the Jovian disk, like a shadow of the 3rd satellite."
- The apparent diameter of this spot estimated from his drawing is about 6 degrees, or 7500km, which is comparable to those of impact spots of class 2a (fragments A, C, E, and H by Hammel et al. 1995, *Science*, Vol. 267, p. 1288).
- The spot was the most distinct feature on Jovian disk by its darkness.
- Its evolution was followed for 18 days until December 23, and its longitudinal length extended continuously with time up to about 29 degrees.
- The lifetime of the visibility of this feature was more than 18 days. This value is also comparable to that of class 2a spots by visual observers (from 9 days for spot A to 35 days for spot H, Rogers J.H., 1996, *J. British Astron. Assn.*, Vol. 106, p. 125).

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A Comet Primer, and Shades of Hyakutake

Christopher Sarnecki

When discussing a great comet with the public it's a good idea to get your terms straight. Useful information never grows old. The first part of this article is gleaned from an article on comets I wrote almost three years ago. The second half is on another way to record your observations in a way you probably haven't thought of.

A typical comet is but a few kilometers across its solid head or nucleus. It has the consistency of a dirty snowball of frozen gases according to the most popular comet formation theory. [Gases detected in comets include carbon monoxide, cyanogen, water, and acetylene - Ed.] When a comet approaches perihelion the nucleus sublimes (evaporates directly from a solid to a gas) and forms a coma – a nebulous, luminescent cloud of gas and dust that may approach the size of the Earth. A dust tail forms which can extend millions of kilometers, the distance from the Earth's orbit to Mars.

A naked-eye comet is a rarity – maybe once (Comet Hyakutake) or twice (Comet Hale-Bopp) in your lifetime. The rest of the time you will have to be content to use your scope, or binoculars if it's a bright one. Following are some tips on how to get a good view of Comet Hale-Bopp:

- Plot the comet's path on the star atlas that you will be using outside. I plot the comet's positions with a permanent marker on a piece of clear film taped to the page of my atlas.
- Note the guide stars on the nights that you will observe. It is with these stars that you will star-hop your way to locating the comet.
- Binoculars and rich-field telescopes are useful to study the tails of the brightest comets.
- Observe far from city lights. Avoid stray light from local sources.
- Use averted vision. Faint objects are more easily seen when you're not looking directly at them. Jiggling the scope slightly often helps. The "standard bonk" can also be used.
- Sketch it! I guarantee that if you sketch anything you will see more after sketching it than before.
- Comets are usually most prominent just before sunrise and just after sunset when they're close to perihelion.

Here are some observing challenges:

- Coma. This is often very faint, but also frequently has some visible structure such as jets and fountains.
- A star-like nucleus. While it is not possible to actually see the nucleus, it is often possible to see a star-like image inside the coma.
- A fan-like coma. This is the start of the dust tail. Remember the dust tail generally points away from the Sun. Make a mental picture of where the Sun is below the horizon to confirm this feature.
- A straight gas tail. Appears bluish in color due to a fluorescence of the gas molecules from solar UV radiation and collisions with particles in the solar wind. The gas tail runs directly away from the Sun and is strongly influenced by the solar wind.
- A curved dust tail. Appearing yellowish in color due to the reflected sunlight. The dust is less affected by the solar wind so it retains the curvature of the orbit.

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Hale-Bopp Watch

Bernard Friberg and Kurt Hillig

Hale-Bopp (also known as Periodic Comet 1995 O1) may well turn out to be the brightest comet of this century. If not, it will certainly be one of the brightest, and those of us who saw Hyakutake will have had the rare privilege of seeing *two* once-in-a-lifetime comets only one year apart.

Hale-Bopp is easily located in the east-northeastern sky before dawn in February and early March; it's already bright enough to be visible to the naked eye, though binoculars can help. The Feb. 8 rise time of H-B (for southeast Michigan) is 4 am, local time, and it rises earlier each day – 3 am on Feb 10, and 2 am on March 20 – making it an easily observed object in the early mornings. A good rule of thumb is to wait an hour or two after the rise time before going out to look for it, to give it time to climb above the horizon; but don't wait too long, as the eastern sky starts to brighten about 1.5 hours before sunrise. 5:30 to 6 am should be a good viewing window for the next week or two; then you'll have to start getting up earlier (or staying up later, if you're a night owl like me – KH).

The path of the comet through the morning skies in February is more or less parallel to the horizon as it heads north. On Feb 12 H-B enters the constellation Vulpecula, and on Feb 24 it enters Cygnus. The path continues into the constellation Andromeda, and H-B will be just above the Andromeda galaxy M31 – only 4 degrees away – on March 25. This is two days past the full Moon, so the skies will be bright if you try to see this in the morning; but H-B will also be visible in the early evening, and you might see a real treat at the end of twilight.

The plane of Hale-Bopp's orbit is nearly perpendicular to the ecliptic plane. On Feb. 10, H-B is 1.8 AU away from the Earth and 1.25 AU from the Sun. H-B is at its closest distance to the Earth – 1.3 AU (about 200 million km) – on March 22, when it lies almost directly above the Sun's north pole; and it makes its closest approach to the Sun (perihelion – 0.91 AU, about 85 million miles, 140 million km) on April 1. [See p. 6 for details - Ed.] So it should be at its brightest from mid-March through mid-April.

As Hale-Bopp moves to the north in February and March, it will become visible in the evening sky as well as in the morning. On Feb 24, H-B will be 9° above the horizon at sunset (6:20 pm), so it will set before twilight ends. By March 15, H-B will be 34° above the horizon at sunset – 10° up at the end of twilight – making it an evening object as well as a morning object for the next month. There's a partial lunar eclipse on March 23, which could make for a nice night of "double-dipping" if the clouds cooperate.

At the beginning of April, Hale-Bopp will be 20° above the northwest horizon at the end of twilight (about 8:30 pm on April 1) and stays about the same for a few weeks while it moves back to the south. Meanwhile, the early birds will see H-B disappear into the morning twilight in mid-April. April 12 is Astronomy Day, and a good time to share H-B with a friend – although with a six day old moon only 30 degrees away, you might want to think about celebrating this one a few days early.

Hale-Bopp crossed the ecliptic plane heading north over a year ago, near Jupiter; but after perihelion, it swings back south in a hurry, crossing the ecliptic again in mid-May. In early May, it will be getting low in the west at sunset, and by the end of the month it will be too far south to be seen from Michigan – unless you're willing to wait 2380 years until its next visit!

Lazy Man's Comet

by Christopher Sarnecki

After reading Stephen O'Meara's article "High-Power Comet Observing" in February's *Sky & Telescope* magazine (pp. 100-101) I resolved to keep a well documented sketch record of Comet Hale-Bopp's perihelion passage. This first view is a word picture.

David Levy's much quoted comparison of comets and cats indicates that – "cats and comets both have tails, and do exactly what they want". I would add, if you want to see a comet you have to do it when the comet decides to make itself visible, even if that means before dawn in the dead of winter.

Having previously done early morning comet observing I can tell you it is *not* easy. Your mind and body are fast asleep when the alarm clock wakes you well before your normal hour. You jump into your clothes trying to remember why some idiot set the alarm four hours before the usual time. Your make a cup of coffee and drag out your observing stuff, all the while your mind is still asleep. You begin your observing run trying to reorient yourself to the stars which moved well into the next season since last night. I usually start my observing run from a bright star and star-hop my way to the comet. In October of 1996, I was observing comet De Vico in the early morning hours. Knowing the position of this comet from the previous night's study; I knew locating this magnitude 6 comet would be a piece of cake. I commenced my observing run without my usual Telrad. "This is easy," I thought, "it's right near Capella." After 10 minutes I ran in the house to get the Telrad. After 10 more minutes I ran inside and grabbed the binoculars. After lying on my back, binoculars in hand, and desperately trying to find Capella, I realized that I wasn't even in the right constellation! Such are the pit-falls of early morning observing.

People ask me, from time to time, how to view a significant astronomical event (read "a bright" object that gets a lot of press). With Comet Hale-Bopp starting to get some press coverage a colleague asked how and were to see this comet. Having previously attempted to view this comet on one of the few, and I mean <u>few</u>, clear mornings on January 6, I realized that I tried to look for this comet too early in the morning. This is a "Lazy Man's Comet" I indicated to my friend. Just look for it at the beginning of morning's twilight and use a finder chart. January and Febuary issues of *Sky & Telescope* have printed some excellent charts in Fred Schaaf's *Stars & Planets* section.

Well, on the morning of January 17th with the temperature at a cool minus 4 degrees the sky was clear. The second clear morning sky this year. The alarm goes off and I get up to check the conditions of the sky from the safety of my house. While it is clear overhead, it is murky on the eastern front. I run down stairs to grab the binoculars, hoping not to wake the Ms. After examining the eastern sky, I realize that no stars are visible in this part of the sky. I decide to study the charts while waiting for the clouds to move out, hopefully before dawn. I perform some celestial navigation. Lets see, where is the Summer Triangle? I find Vega and confirm it by checking for Epsilon Lyrae. Then locating Deneb I plot my way down the neck of the swan to Albireo. I know that comet Hale-Bopp is above Altair, the third member of the Summer Triangle. Finally I realize it is time to move to a window that is better optimized from looking due east and low on the horizon for this star. The only window is right near were the Ms is sleeping. Oh well, once again I think "Sure hope I don't wake her" and proceed to open the blinds.

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The Lives of the Comets

Kurt Hillig

Just what are comets, anyway? Where did they come from? Why do they have such wierd orbits? What are they made from? How may comets are there? What do they mean?

These and many other questions have puzzled astronomers, astrologers, and just plain folks for thousands of years. The recorded history of comets goes back nearly as far as recorded history itself. In pre-telescope days, comets were often thought to be messengers from the Gods, or omens of doom. (This is due to the "full moon effect" – the claim by many delivery room nurses that there are more babies born when the moon is full than at other times. The real reason for this is that people are more likely to remember events that are accompanied by another dramatic event. So the appearance of Halley's comet over the Battle of Hastings in 1066 "confirms" that comets are associated with catastrophe.)

To the ancient Greeks, comets had a less mystical explanation: they were exhalations from the Earth, or perhaps hairy, wandering stars (the word "comet" derives from the word for hair, just as "planet" comes from the word for wanderer). The natural and supernatural interpretations clashed – at least in western cultures – until the Renaissance, and the invention of the telescope (and, indeed, long after). With Newton and the mathematics of gravity, comets moved completely into the world of the natural – although we still find them to be rather extraordinary sights to see!

But are they extraordinary? Just what are they, really? To answer this, we need to look back in time – not to the beginning of recorded history, but to the darkness before the dawn of the solar system. Set the Wayback Machine for five billion BC, Sherman!

Before the Sun was born, we were a cloud. A big cloud, tens of light-years across, with the mass of a thousand Suns, filled with dust and gas, an organic soup of molecules as tenuous as the best laboratory vaccuums today. Something like M8, or M42, in other words! Shock waves from nearby supernovae rippled through it, compressing it; and where the density rose, the self-gravity of that knot of matter drew in more material, and it started to condense. After a few tens or hundreds of millions of years, the proto-Solar System was a dense vortex a few thousand AU across.

In the center, a star was beginning to form. Further out, smaller eddys were condensing to form bodies anywhere from a millimeter to tens of thousands of kilometers across. Heat from the evolving protostar kept the volatile materials – hydrogen, ammonia, carbon monoxide, etc. from condensing in the inner regions; but at the outer edges, shielded from the inner heat by the dense cloud, the comets grew. At temperatures only a few degrees above absolute zero, they slowly grew; dry-ice hailstones at 15°K.

In the inner part of the nebula, the star caught fire, and the innermost clumps were baked dry; but the outer planets swept up the escaping gas, and grew, and played catch with the millions of smaller bodies that littered the system. Over the next billion years or so, the inner planets were bombarded with rocks, and with the comets that came in too close; Something big hit Uranus-to-be, hard enough to knock it on its side; something the size of Mars struck the proto-Earth, breaking loose what would someday be called Luna. Another billion years, and something big brushed past Neptune, flinging its moons across the sky; two of the escapees formed a partnership, calling themselves Pluto and Charon.

Meanwhile, back at the 1000 AU ranch we call the Oort Cloud, the primordial comets slowly wove their way thorough space. Barely feeling the tug of the Sun, they creep along like snails; too far out to have been caught in the vortex, they move in all directions. Every few million years, a wandering planet, flung out aeons ago from some stellar system (not necessarily ours), or perhaps a wandering star, comes close enough to wake them from their sleep, and send a few drifting in towards us; and after another few thousand years, some make it close enough for us to see.

It is estimated that there are as many comets orbiting our Sun as there are stars in the Milky Way; and they range in size from a few tens of meters to perhaps a hundred kilometers or so. Some are more rock, some are mostly gas; some are captured when they come in, and forced into short-period orbits where they evaporate quickly, leaving trails of dust that form our brightest meteor showers; some are flung out to travel forever across the universe. Some fall straight into the Sun, or into Jupiter; many have hit the Earth (it is thought by some that most of our water and atmosphere came from comets).

Some, like Hyakutake and Hale-Bopp, come by only rarely, with periods of thousands, tens of thousands of years. Like dirty snowballs that spend most of their time in a deep freeze, they still retain much of the volatile gas that they started with; and when the geometry is right, they make close passes by both the Sun and the Earth, yielding spectacular sights. Surrounded by a swarm of pebbles, the smaller grains and dust trail out along the orbital path to yield a tail yellow from reflected sunlight. The evolving gas, driven by the solar wind, ionized by solar ultraviolet, and warped by the solar magnetic fields, provides a blue-green fluorescence that can glow for a hundred million miles. Comet quakes calve off icebergs, exposing fresh surfaces that erupt in towering jets.

And we on Earth – a species which has existed for a mere fraction of the lifetime of the comets – we stand outside at night in awe and in silence, and we dream, and wonder....

Lazy Man's Comet *continued from p. 3*

As luck would have it the clouds in the east are starting to move out. At approximately 6:40 am I locate Altair, offset my eyes as indicated on the finder chart, and voila! There is the comet! Shining with an unmistakable fuzzy glow in the binoculars, well up above 10 degrees.

With the Sun now having noticeable effect on the morning's darkness I decide to race downstairs and get the 85 mm finder scope on this comet. Still in my pajamas I throw on my boots and coat and attach the small scope to a tripod. Then out into the minus 4 degree temperature I go. A neighbor's dog immediately indicates his displeasure with my arrival on the driveway and runs off to do his thing in somebody else's yard. This is madness I think; it's dark, I'm outside in my pajamas, in minus 4 degree temperature, with a dog about to attack, and I am looking over my neighbor's house with a telescope. I fumble some more with the scope (now how do I tighten this thing down to the tripod?). Finally, I somehow manage to locate the comet and bring it to focus. The sky is still murky but there it is, plain as, well, as a comet on a cold January morning. With a star-like nucleus embedded in a nice little coma, and suggestions of a faint text-book tail I think "I gotta do more of this." Almost immediately the Sun brings this observing run to a close. I think to myself, not a bad way to start the day of your 45th birthday – with an OLD Lazy Man's Comet.

Shades of Hyakutake *continued from p. 2*

Here is another exercise to help you enjoy and remember Comet Hale-Bopp. Record your observations in writing. Here are my observations of last year's great Comet Hyakutake:

February 24, 1996: Observed a 7th mag comet Hyakutake with fellow Lowbrows at Peach Mt. *March 16:* Messier Night at Lake Hudson. Cloudy weather brings the night to a close after most observers make it through the Coma-Virgo cluster. With over 30 observers, seven of whom were Lowbrows, first observed comet Hyakutake naked-eye coming over the horizon in Libra. This is going to be a great comet! *March 20:* From Shanty Creek in northern Michigan were I am attending a conference. Comet Hyakutake is observed with a tripod mounted finder scope. With the dark skies up here I am almost knocked off my feet by the strong blue color of this comet and it's five degree tail. *March 22:* Find my neighbor wandering in my back yard looking for the comet. "It's in the front yard," I say. The clouds roll in almost immediately, but incredibly the comet can be seen through the thinner sections of the clouds with the naked-eye. *March 23:* Hundreds of people descend on the Lowbrow's open house at Peach Mt. to catch the comet. I come to the conclusion that this comet is best enjoyed without any optical aids; but, not before making the biggest mistake of this great comet's apparition. In a low powered view through the telescope I notice a "spike" coming out the back of the nucleus. Embarrassed, I put the scope away thinking I really must collimate the optics. Later I read numerous reports of a significant but short lived jet or fountain of material leaving the nucleus. You can bet this is a mistake I will not make again! *March 26:* Comet Hyakutake is at its brightest. It is a Tuesday night and about 25 people show up at Peach Mt. Many taking photos with their cameras riding the 24 inch McMath telescope. I make a sketch. Visually the tail extends over 25 degrees! I learn the definition of "sublime" tonight and am awe struck by the grandeur of the moment. *April 3:* Observe the comet during a total eclipse from Williamsburg Va. were we are vacationing. The comet has become a familiar sight in the night's sky even if it will be short lived. *Mid-April:* My last sight of the comet is in the western twilight. The head of the comet is pointing sunward and the smaller tail is pointing almost straight up.

When I read these short statements I relive the comet's passage in my mind and see it as clearly as the night it was observed.

Cassini's Comet Crash *continued from p. 2*

The strongest evidence for convincing them is the recorded time variation of over 18 days. Such a long-term evolution was never found in other candidates surveyed so far. The spot became crescent shape, and extended to about 10 degrees in the longitudinal direction after 10 days from its appearance. Immediately after this epoch, it was seen as fragmented dark patches. On 14 days after the appearance, two patches merged again to one long filament-like structure. The final situation after 18 days shows three narrow patches lying in the longitudinal direction. The eastern patch clearly shows the effect of the wind shear or of the unseen atmospheric structure such as vortexes. Such evolution is similar to the H impact site observed by the Hubble Space Telescope in the case of Comet Shoemaker-Levy. The average growth rate of the elongation was 0.6 degrees per day, which corresponds to 8.6 m/s of the zonal wind shear at this latitude.

They carried out a simple simulation, assuming that the initial spot was produced by the ejecta of the impact, and applied the reduced wind speeds measured by the Voyager spacecraft, and confirmed that the primary effect of the time variation is simply zonal wind shear, the same as in the cases of the SL-9 spots. They concluded that this spot was probably produced by an impact of a single astronomical object, the size of which was comparable to those of fragments A, C, or E of the SL-9. Because there is no other spot during the studied period, the impact body may have been a single object.

This discovery of a possible impact spot also reminds us of the importance of data archives, which may produce new insights to science for the future. The library work in the Paris Observatory is a typical example of the excellent effort to preserve such historical records. The drawings may even result in significant findings in the future. It should be stressed that we should take care of archiving astronomical data for the astronomers of the next generation.

This work will be published as "Discovery of a Possible Impact Spot on Jupiter Recorded in 1690", Tabe, I., Watanabe, J. and Jimbo, M., *Pub. Astron. Soc. Japan* (Letter), No.1 Vol. 49, 1997. A copy of this paper is available at www.nao.ac.jp/whatsnew/jup/index-e.html

Comet 1997 A1 (NEAT)

Congratulations to Eleanor Helin and her NEAT team for discovering the first comet of 1997! The comet discovery was reported in IAU Circular 6532 on January 11, 1997. The comet is designated 1997 A1 and was observed as an 18.6 magnitude object with a 1-meter telescope on Haleakala in Maui, Hawaii.

NEAT is a Near Earth Asteroid Tracking program run from here at JPL. Images of the new comet are available on the NEAT home page: http://huey.jpl.nasa.gov/~spravdo/neat.html

IAU Circular 6532 is available at http://cfa-www.harvard.edu/cfa/ps/Headline/06532.html

Scope for Sale!

Darren Roulstone <roulston@umich.edu>

Last year I made the mistake (of which I'd been warned!) of purchasing too large a telescope – a Meade 8" f/6 reflector. It's a great telescope but not easy for me to transport. I'm interested in selling it and acquiring a smaller scope – I'd consider a reasonably priced 8" SCT or a smaller scope in trade. Here are some specs:

- 8" f/6 Newtonian reflector
- 8x50 Finder
- 2" focuser with 1.25" adapter
- Equatorial mount with A/C drive and plugin
- Meade 25mm MA eyepiece (48X)
- Meade instruction manual

It's an older scope but in very good condition. The tube is strong and light (not sonotube). The mount has felt-lined cradle rings instead of straps. The scope has been very well taken care of – its previous owner is Ron Netzly, an avid amateur astronomer from Troy, Ohio. The price is $525 and I can drive a few hours to drop it off or we can work out a shipping arrangement. You are welcome to come by to see the scope if you're interested in it – give me a call, at (313) 763-3712 (office), or 763-9563 (home).

Orbit and Ephemeris Information for Comet 1995 O1 Hale-Bopp

Don Yeomans, NASA/JPL

JPL reference solution no. 48, based on planetary ephemeris DE403, 1772 observations covering 1993 Apr 27 through 1997 Jan 19. The corrected elements (J2000) for epoch 2450571.50000 (= 1997 May 3.00000 UT) are as follows:

Element	Value	Std.Dev.	Definition
e	0.995107808	.000001002	Eccentricity
q	0.914103842	.000001861	Perihelion passage distance (AU)
I	89.4293189	.0000336	Inclination (deg.)
w	130.5910110	.0000886	Argument of perihelion (deg.)
Node	282.4708075	.0000054	Longitude of the ascending node (deg.)
Tp	2450539.6353558	.0002557	Time of perihelion passage (Julian)

(Tp = 1997 Apr 1 03:14:55 UT)

By integrating the orbit forward and backward in time until the comet leaves the planetary system and then referring the osculating orbital elements to the solar system barycenter, the following orbital periods result:

Original orbital period before entering planetary system = 4200 years

Future orbital period after exiting planetary system = 2380 years

Ephemeris data at 1 day steps (0 hours UTC)

Delta is the geocentric distance in AU; **r** is the heliocentric distance in AU. **Theta** is the Sun-Earth-Object angle, **Beta** is the Sun-Object-Earth angle, and **Moon** is the Moon-Earth-Object angle in degrees. **Tmag** is the total magnitude, calculated by the formula Tmag = 5.00*log(Delta) + 7.5*log(r)

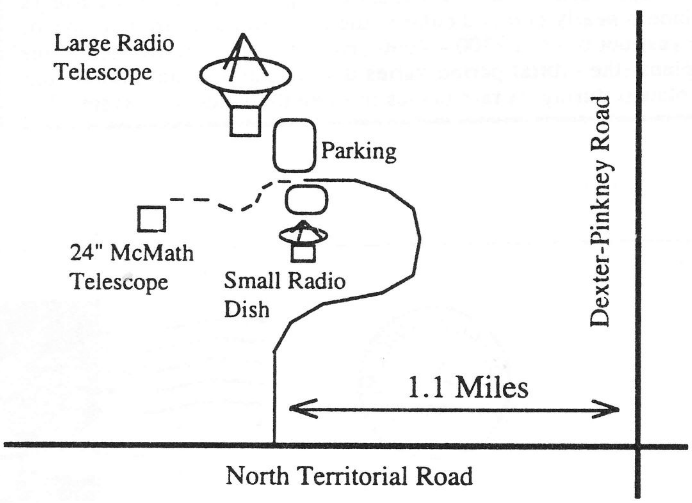
Date (UT)	R.A. J2000	Dec.	Delta	r	Theta	Beta	Moon	Tmag
1997 Feb 15	20 20 53.80	+23 18 26.9	1.730	1.207	42.7	33.7	107	1.8
1997 Feb 16	20 24 24.00	+23 57 20.0	1.711	1.196	43.0	34.3	116	1.8
1997 Feb 17	20 28 00.58	+24 36 55.2	1.693	1.186	43.3	34.8	123	1.7
1997 Feb 18	20 31 43.89	+25 17 11.8	1.674	1.175	43.5	35.4	130	1.6
1997 Feb 19	20 35 34.29	+25 58 08.8	1.656	1.164	43.8	36.0	135	1.6
1997 Feb 20	20 39 32.15	+26 39 45.0	1.638	1.154	44.0	36.6	138	1.5
1997 Feb 21	20 43 37.85	+27 21 58.7	1.620	1.144	44.3	37.1	140	1.5
1997 Feb 22	20 47 51.82	+28 04 48.1	1.602	1.134	44.5	37.7	139	1.4
1997 Feb 23	20 52 14.48	+28 48 11.1	1.585	1.124	44.7	38.3	136	1.4
1997 Feb 24	20 56 46.27	+29 32 04.9	1.568	1.114	44.9	38.9	131	1.3
1997 Feb 25	21 01 27.66	+30 16 26.5	1.552	1.104	45.1	39.4	125	1.3
1997 Feb 26	21 06 19.13	+31 01 12.4	1.535	1.095	45.3	40.0	119	1.2
1997 Feb 27	21 11 21.17	+31 46 18.6	1.519	1.086	45.5	40.6	112	1.2
1997 Feb 28	21 16 34.30	+32 31 40.4	1.504	1.076	45.6	41.1	104	1.1
1997 Mar 1	21 21 59.01	+33 17 12.8	1.489	1.067	45.7	41.7	96	1.1
1997 Mar 2	21 27 35.82	+34 02 50.0	1.474	1.059	45.9	42.2	88	1.0
1997 Mar 3	21 33 25.25	+34 48 25.5	1.460	1.050	46.0	42.7	80	1.0

Date (UT)	R.A. J2000	Dec.	Delta	r	Theta	Beta	Moon	Tmag
1997 Mar 4	21 39 27.80	+35 33 52.3	1.447	1.042	46.0	43.3	72	0.9
1997 Mar 5	21 45 43.95	+36 19 02.5	1.434	1.033	46.1	43.8	64	0.9
1997 Mar 6	21 52 14.15	+37 03 47.6	1.421	1.025	46.2	44.3	57	0.8
1997 Mar 7	21 58 58.84	+37 47 58.5	1.409	1.018	46.2	44.7	51	0.8
1997 Mar 8	22 05 58.36	+38 31 25.1	1.398	1.010	46.2	45.2	47	0.8
1997 Mar 9	22 13 13.04	+39 13 57.0	1.387	1.003	46.2	45.7	45	0.7
1997 Mar 10	22 20 43.07	+39 55 22.8	1.377	0.996	46.2	46.1	46	0.7
1997 Mar 11	22 28 28.60	+40 35 30.7	1.368	0.989	46.2	46.5	50	0.6
1997 Mar 12	22 36 29.62	+41 14 08.6	1.360	0.982	46.2	46.9	55	0.6
1997 Mar 13	22 44 46.01	+41 51 03.9	1.352	0.976	46.1	47.2	62	0.6
1997 Mar 14	22 53 17.48	+42 26 03.8	1.344	0.970	46.0	47.6	69	0.5
1997 Mar 15	23 02 03.60	+42 58 55.6	1.338	0.964	46.0	47.9	76	0.5
1997 Mar 16	23 11 03.72	+43 29 26.7	1.332	0.959	45.9	48.1	83	0.5
1997 Mar 17	23 20 17.03	+43 57 24.9	1.328	0.953	45.7	48.4	90	0.5
1997 Mar 18	23 29 42.49	+44 22 38.6	1.323	0.948	45.6	48.6	97	0.4
1997 Mar 19	23 39 18.89	+44 44 57.2	1.320	0.944	45.5	48.8	104	0.4
1997 Mar 20	23 49 04.80	+45 04 11.1	1.318	0.940	45.3	48.9	110	0.4
1997 Mar 21	23 58 58.62	+45 20 12.0	1.316	0.936	45.2	49.0	117	0.4
1997 Mar 22	00 08 58.59	+45 32 53.1	1.315	0.932	45.0	49.1	123	0.4
1997 Mar 23	00 19 02.84	+45 42 09.4	1.315	0.929	44.8	49.1	129	0.4
1997 Mar 24	00 29 09.38	+45 47 57.5	1.316	0.926	44.6	49.1	134	0.3
1997 Mar 25	00 39 16.18	+45 50 16.2	1.318	0.923	44.4	49.1	138	0.3
1997 Mar 26	00 49 21.21	+45 49 06.0	1.320	0.921	44.1	49.0	140	0.3
1997 Mar 27	00 59 22.47	+45 44 29.4	1.323	0.919	43.9	48.9	141	0.3
1997 Mar 28	01 09 18.03	+45 36 30.6	1.327	0.917	43.7	48.7	138	0.3
1997 Mar 29	01 19 06.07	+45 25 15.6	1.332	0.916	43.4	48.5	134	0.3
1997 Mar 30	01 28 44.92	+45 10 51.9	1.338	0.915	43.1	48.3	128	0.3
1997 Mar 31	01 38 13.11	+44 53 28.3	1.344	0.914	42.9	48.0	120	0.4
1997 Apr 1	01 47 29.30	+44 33 14.7	1.351	0.914	42.6	47.7	111	0.4
1997 Apr 2	01 56 32.42	+44 10 21.8	1.359	0.914	42.3	47.4	101	0.4
1997 Apr 3	02 05 21.54	+43 45 01.1	1.367	0.915	42.0	47.0	91	0.4
1997 Apr 4	02 13 55.96	+43 17 24.2	1.376	0.916	41.7	46.6	80	0.4
1997 Apr 5	02 22 15.17	+42 47 43.2	1.385	0.917	41.4	46.2	69	0.4
1997 Apr 6	02 30 18.84	+42 16 10.0	1.396	0.918	41.1	45.7	57	0.4
1997 Apr 7	02 38 06.77	+41 42 56.3	1.406	0.920	40.7	45.2	46	0.5
1997 Apr 8	02 45 38.94	+41 08 13.8	1.418	0.922	40.4	44.7	37	0.5
1997 Apr 9	02 52 55.43	+40 32 13.3	1.430	0.925	40.1	44.2	29	0.5
1997 Apr 10	02 59 56.45	+39 55 05.5	1.442	0.928	39.7	43.6	26	0.6
1997 Apr 11	03 06 42.28	+39 17 00.3	1.455	0.931	39.4	43.1	29	0.6
1997 Apr 12	03 13 13.28	+38 38 07.0	1.468	0.935	39.0	42.5	35	0.6
1997 Apr 13	03 19 29.87	+37 58 34.4	1.482	0.938	38.7	41.9	43	0.6
1997 Apr 14	03 25 32.50	+37 18 30.3	1.496	0.943	38.3	41.3	52	0.7
1997 Apr 15	03 31 21.69	+36 38 02.3	1.510	0.947	37.9	40.6	62	0.7
1997 Apr 16	03 36 57.93	+35 57 17.1	1.525	0.952	37.6	40.0	72	0.8

Places:

Dennison Hall, also known as the University of Michigan's Physics and Astronomy building, is located on Church Street in Ann Arbor, one block north of South University Ave. The University parking structure on Church Street is very close by, and is open to the public after 6 PM.

Peach Mountain Observatory is the home of the University of Michigan's 25-meter radio telescope, as well as the University's McMath 24-inch telescope which is maintained by the Lowbrows. The observatory is located northwest of Dexter; the entrance is on North Territorial Road, 1.1 miles west of Dexter-Pinckney Road. A small maize-and-blue sign marks the gate. Follow the gravel road one mile to a parking area near the radio telescopes. Walk along the path between the two fenced-in areas (about 300 feet) to reach the McMath telescope building. Peach Mountain is home to millions of mosquitos in the summer, so bring insect repellant!



Times:

The monthly meetings of the Lowbrows are held on the third Friday of each month at 7:30 PM in 807 Dennison Hall. During the summer months, and when weather permits, a club observing session at Peach Mountain will follow the meeting.

An amateur telescope making group meets monthly, with the location rotating among members' houses. See the calendar on the front cover for more information on the time and location of the next meeting.

Public Open House/Star Parties are held on the Saturdays before and after each new Moon, at the Peach Mountain Observatory. Star Parties may be cancelled if the sky is cloudy at sunset or the temperature is below 10°F – call 480-4514 to check on the status. Many members bring their telescopes; visitors are welcome to do likewise. Peach Mountain can get cold at night, so dress appropriately!

Membership:

Membership dues in the Lowbrow Astronomers are $20 per year for individuals or families, and $12 per year for students. This entitles you to monthly issues of *Reflections* and the use the 24" McMath telescope (after training). Dues can be paid to the club treasurer, Doug Scobel, at any meeting or by mail at this address:

1426 Wedgewood Dr.
Saline, MI 48176

Magazines:

Members of the Lowbrow Astronomers can get a discount on these magazine subscriptions:

Sky and Telescope: $27 / year
CCD Astronomy: $20 / year
Astronomy: $20 / year
Odyssey: $16.95 / year

For more information, contact the treasurer.

Newsletter Contributions:

Members (and non-members) are encouraged to write about any astronomy-related topic in which they are interested. Images, whether photographs, sketches, or in electronic form (GIF, TIFF or JPEG) are also welcome. Call the editor - Kurt Hillig - at (313) 663-8699(home) or (313) 647-2867(office), or send e-mail to khillig@umich.edu, to discuss format, etc. Announcements and articles are due 14 days before each monthly meeting. Contributions can be mailed to:

Kurt Hillig
7654 W. Ellsworth Rd.
Ann Arbor, MI 48103

Telephone Numbers:

President:	D. C. Moons	810/254-9439
Vice Pres:	Mark Cray	313/283-6311
	Tom Pettit	313/878-0438
	Fred Schebor	313/426-2363
	Mark Vincent	313/663-7813
Treasurer:	Doug Scobel	313/429-4954
Observatory Director:	Bernard Friberg	313/761-1875
Newsletter:	Kurt Hillig	313/663-8699
Publisher:	Lorna Simmons	313/525-5731

Peach Mountain Keyholder:
Fred Schebor 313/426-2363

Visit our Home Page:

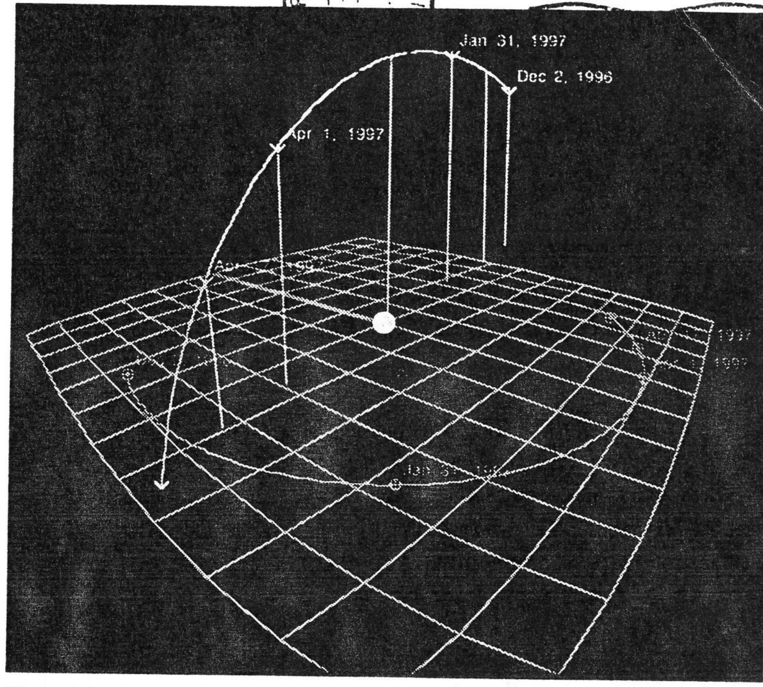
http://www.astro.lsa.umich.edu/lowbrows.html

Monthly Meeting:

Everything You Always Wanted to Know About Comets (but were afraid to ask)

Feb. 21, 1997 at 7:30 PM

Room 807 of the Dennison Building on the UM Campus



The orbit of comet Hale-Bopp loops over the Sun, above the Earth's orbit. The closest approach to the Sun occurs on April 1, 1997. Hale-Bopp's orbital plane is nearly perpendicular to the plane of the ecliptic; it spends only one year out of each 2300 – 4000 year orbit on the north side of the ecliptic plane (the orbital period varies due to gravitational interactions with the planets during its rare passes through the inner solar system.)

University Lowbrow Astronomers
1740 David Ct.
Ann Arbor, MI 48105

Check your membership expiration date on the mailing label!