Star Stuff

The Ford Amateur Astronomy Club Newsletter

Volume 5, Number 4 April 1996

HUBBLE REVEALS SURFACE OF PLUTO FOR FIRST TIME

For the first time since its discovery 66 years ago, astronomers have at last directly seen details of Pluto's surface. Hubble's snapshots of nearly the entire surface, taken as the planet rotated through a 6.4-day period, show that Pluto is a complex object, with more large-scale contrast than any planet, except Earth. The images also reveal almost a dozen distinctive albedo features, or provinces, none of which have ever been seen before. They include a "ragged" northern polar cap bisected by a dark strip, a bright spot seen rotating with the planet, a cluster of dark spots, and a an intriguing bright linear marking. The images confirm the presence of icy-bright polar cap features, which had been inferred from indirect evidence for surface markings in the 1980s.

This historic new look at Pluto helps pave the way for a proposed Pluto flyby mission early in the next century. Pluto is the only solar system planet not yet visited by a spacecraft. "Hubble is providing the first, tantalizing glimpse of what Pluto will be like when we get there," said team leader Dr. Alan Stern of Southwest Research Institute. The Pluto imaging team also includes Dr. Marc Buie of Lowell Observatory, and Dr. Laurence Trafton of the University of Texas. This team of planetary scientists used the Faint Object Camera aboard the Hubble to obtain over a dozen high-quality visible and ultraviolet images of Pluto in mid-1994. These images have now been carefully reduced and analyzed.

"These results and the maps we constructed from them are much better than I ever hoped for," said Dr. Buie. "It's fantastic. Hubble has brought Pluto from a fuzzy, distant dot of light, to a world which we can begin to map, and watch for surface changes. Hubble's view of tiny, distant Pluto is reminiscent of looking at Mars through a small telescope," said Stern. Some of the sharp variations across Pluto's surface detected in the Hubble images may potentially be caused by such topographic features as basins and fresh impact craters (as found on Earth's Moon). However, most of the surface features unveiled by Hubble are likely produced by the complex distribution of frosts that migrate across Pluto's surface with its orbital and seasonal cycles. Pluto is so far from the Sun that even nitrogen, carbon monoxide, and methane gases partially freeze onto its surface during the long period (about 100 years) when it is farthest from the Sun.

The Hubble images reveal much more surface variety on Pluto than on other icy objects in the outer solar system, including Pluto's oft-cited twin, Neptune's large moon Triton. According to Dr. Trafton, "...the HST images are confirming Pluto's individuality. It isn't a twin of Triton after all." During the short, warm season around Pluto's closest approach to the Sun, these ices sublimate (go directly back to a gas), thickening Pluto's atmosphere. "The light areas are as bright as fresh Colorado snow, and the darker areas are more reminiscent of the brightness of a dirty snow," said Stern. The darkest regions likely result from hydrocarbon "residues" from the effects of ultraviolet sunlight and cosmic rays on Pluto's complex chemical melange of surface ices.

Pluto is two-thirds the size of Earth's Moon, and 1,200 times farther away. Pluto's apparent size in the sky is so small (0.1 arcseconds), that 18,000 Plutos would need to be lined up to match the diameter of the full Moon. This puts Pluto's surface below the resolution limit of the largest ground-based telescopes; as a result it has been impossible to directly see any significant detail on Pluto before these Hubble observations. Viewing such a remote and small body has been so difficult that Pluto's moon Charon wasn't detected until 1978, despite the fact that Pluto itself was discovered by Clyde Tombaugh in 1930. Shortly after its launch in 1990, the Hubble Space Telescope first peered at Pluto and clearly distinguished the planet and its satellite (which is only 1/3,000th of a degree away) as two separate objects. However, a detailed look at Pluto's surface had to wait until Hubble's optics were improved during the late-1993 servicing mission.

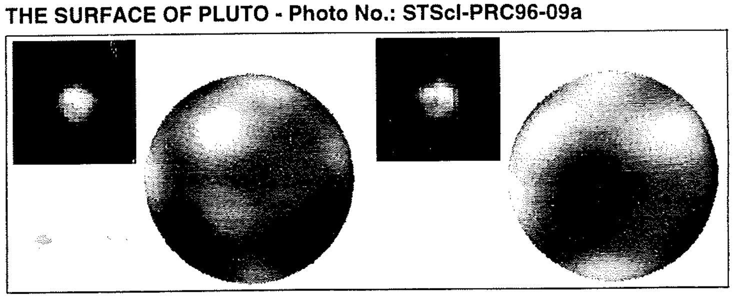
SCIENCE BACKGROUND

Super-Comet or Ice Dwarf?: Pluto is so unique it almost defies classification. Though it orbits the Sun, Pluto neither qualifies as a terrestrial nor as a gas giant planet. Though it behaves like a comet by periodically warming and losing its atmosphere into space, Pluto is far too large for that category. Pluto may be the last survivor of a lost population of objects called ice dwarfs that inhabited the primeval solar system. Neptune's moon Triton might be a distant cousin, and other relatives may dwell in the Kuiper Belt. Pluto and Triton survive because they have found gravitational niches in the solar system where they remain in stable orbits. Pluto is in a resonance orbit with Neptune (Neptune circles the Sun three times for every two orbits of Pluto), which means that Pluto never gets close enough to Neptune to be thrown out the solar system. Triton was gravitationally captured by Neptune and was therefore prevented from being ejected from the planetary region. It is believed that all of the other ice dwarfs formed inside 50 AU were ejected by gravitational interactions due to the giant planets.

The Double Planet: Pluto and Charon is the best example of a double planet, which occurs when two bodies are reasonably close in mass and so orbit around a common center of gravity - or barycenter. Charon may have been born through a head-on collision between Pluto and another large ice body. According to computer models, some of the debris from this giant impact on Pluto went into orbit around Pluto and coalesced to form Charon.

A Dynamic, Unique Atmosphere: Despite its small size and remote location, Pluto undergoes dramatic seasonal changes driven largely by its highly elliptical orbit, which carries it as close as 2.8 billion miles to the Sun (inside Neptune's orbit) and as far as 4.6 billion miles from the Sun. As Pluto recedes from the Sun, much of its atmosphere is believed to freeze out onto the surface. This explains the abundance of fresh white ice on the surface. Pluto essentially "launders" its surface by evaporating dirty, old ice in the summer, and depositing a fresh new layer of ice each 248-year orbit. Pluto passed its closest point to the Sun in late 1989. As a result, it presently enjoys a relatively "balmy" surface temperature near -350° Fahrenheit in the dark areas, and a cooler -380° in the ice areas. It is likely that this sets up tremendous pressure differences at the surface, creating high wind speeds in Pluto's tenuous atmosphere.

THE SURFACE OF PLUTO - Photo No.: STScI-PRC96-09a



Pluto itself probably shows even more contrast and perhaps sharper boundaries than is shown here, but Hubble's resolution tends to blur edges and blend together small features sitting inside larger ones. The two smaller inset pictures are the actual images from Hubble. North is up. Each square pixel is more than 100 miles across. At this resolution, Hubble discerns roughly 12 major "regions" where the surface is either bright or dark. The larger images are from a global map constructed through computer image processing. The tile pattern is an artifact of the image enhancement technique. Opposite hemispheres of Pluto are seen in these two views. The picture was taken in blue light when Pluto was at a distance of 3 billion miles from Earth. ☆

GALAXY CLUSTER FORMATION

PR 05/96 from the European Southern Observatory

In the context of a comprehensive Key-Programme, carried out with telescopes at the ESO La Silla Observatory, a team of European astronomers has recently obtained radial velocities for more than 5600 galaxies in about 100 rich clusters of galaxies. With this programme the amount of information about the motions of galaxies in such clusters has almost been doubled. This has allowed the team to study the distribution of the cluster masses, and also the dynamical state of clusters in new and interesting ways. An important result is that the derived masses of the investigated clusters of galaxies indicate that the mean density of the Universe is insufficient to halt the current expansion; we may therefore be living in an open Universe that will expand forever.

CLUSTERS OF GALAXIES AS TRACERS OF LARGE-SCALE STRUCTURE

About 40 years ago, American astronomer George Abell, working at the Palomar Observatory in California, was the first to perform a systematic study of rich clusters of galaxies, that is clusters with particularly many member galaxies located within a relatively restricted region in the sky. He identified several thousands of such clusters, and he numbered and described them; they are now known to astronomers as 'Abell clusters'.

More than twenty years earlier, Swiss-American astronomer Fritz Zwicky, using the famous 100-inch Mount Wilson telescope above Los Angeles, concluded that the total mass of a rich cluster of galaxies is probably much larger than the combined mass of the individual galaxies we can observe in it. This phenomenon is now known as the 'Missing Dark Matter', and many attempts have since been made to understand its true nature. Although the existence of this Dark Matter is generally accepted, it has been very difficult to prove its existence in a direct way. Rich clusters have several components: in addition to several hundreds, in some cases even thousands of galaxies (each with many billions of stars and much interstellar matter), they also contain hot gas (with a temperature of several million degrees) which is best visible in X-rays, as well as the invisible dark matter just mentioned. In fact, these clusters are the largest and most massive objects that are known today, and a detailed study of their properties can therefore provide insight into the way in which large-scale structures in the Universe have formed. This unique information is encoded into the distribution of the clusters' total masses, of their physical shapes, and not the least in the way they are distributed in space.

THE NEED FOR A 'COMPLETE' CLUSTER SAMPLE

Several of these fundamental questions can be studied by observing just a few well-chosen clusters. However, if the goal is to discriminate between the various proposed theories of formation of their spatial distribution and thus the Universe's large-scale structure, it is essential that uniform data is collected for a sample of clusters that is complete in a statistical sense. Only then will it be possible to determine reliably the distribution of cluster masses and shapes, etc. For such comprehensive investigations, 'complete' samples of clusters (that is, brighter than a certain magnitude and located within a given area in the sky) can be compiled either by means of catalogues like the one published by Abell and his collaborators and based on the distribution of optically selected galaxies, or from large-scale surveys of X-ray sources.

However, in both cases, it is of paramount importance to verify the physical reality of the presumed clusters. Sometimes several galaxies are seen in nearly the same direction and therefore appear to form a cluster, but it later turns out that they are at very different distances and do not form a physical entity. This control must be performed through spectroscopic observations of the galaxies in the candidate clusters. Such observations are crucial, as they not only prove the existence of a cluster, but also determine its distance and provide information about the motion of the individual galaxies within the cluster.

THE ESO NEARBY ABELL CLUSTER SURVEY (ENACS)

Until recently, there existed no large cluster sample with extensive and uniform data on the motions of the individual galaxies. But now, in the context of an ESO Key-Programme known as the ESO Nearby Abell Cluster Survey or ENACS, the team of European astronomers has collected spectroscopic and photometric data for a substantial sample of more than one-hundred, rich and relatively nearby southern clusters from the Abell catalogue. The extensive observations were carried out with the OPTOPUS multi-fibre spectrograph attached to the ESO 3.6-metre telescope at the La Silla Observatory, during 35 nights in the period from September 1989 to October 1993. With this very efficient spectrograph, the spectra of about 50 galaxies could be recorded simultaneously, dramatically reducing the necessary observing time. In total, the programme has yielded reliable radial velocities for more than 5600 galaxies in the direction

(continued on page 6)

STAR STUFF
Monthly Publication of the Ford Amateur Astronomy Club

Star Stuff Newsletter
P.O. Box 7527
Dearborn, Michigan 48121-7527

1996 CLUB OFFICERS

President:	Bob MacFarland	33-79750
Vice President:	Patti Forton	84-51740
Secretary:	Harry Kindt	313-835-1831
Treasurer:	Kevan Granat	24-87628

GENERAL MEETINGS

The Ford Amateur Astronomy Club holds regular general meetings open to the public on the fourth Thursday of the month at 5:00 PM. Meetings are held at the Ford Motor Credit Company (FMCC) building, Northeast of the World Headquarters build in Dearborn, in conference room 1491, lower floor, East side of the building.

OBSERVING SITE

The Ford Amateur Astronomy Club has an established observing site, by permit, at the Spring Mill Pond area of the Island Lake Recreational Area in Brighton, Michigan located near the intersections of I-96 and US-23. Members are responsible for opening and closing the gate after the parks 10:00pm closing time. The combination for the lock should be available on our hotline number. Always close the gate behind you after 10:00pm whether entering or leaving the park.

OBSERVING HOTLINE NUMBER - (313) 39-05456

On Friday and Saturday nights, or nights before holidays, you can call the hotline number up to 2 hours before sunset to find out if we will be observing that night. Assume that any clear Friday or Saturday night is a candidate observing night unless something else is going on or none of the club officers are able to make it.

MEMBERSHIP AND DUES

Membership to the Ford Amateur Astronomy Club is open to both Ford and Non-Ford Motor Company employees. The general public is also welcome to join. The dues structure is as follows:

Annual Individual/Family	$20.00
Lifetime Membership	$100.00

Membership benefits include a subscription to the Star Stuff newsletter, discounts on subscriptions to Astronomy and/or Sky & Telescope magazine(s), after hour use of the observing site at Island Lake, and discounts at selected area astronomical equipment retailers.

NEWSLETTER STAFF

Editor:	Paul Mrozek PROFS: pmrozek; MD 3014 Building 3 pmrozek@av3168.pd8.ford.com pmrozek@ford.com (outside of Ford)	313-33-73619
Contributing Editors:	Greg Burnett	313-84-53586

NEWSLETTER SUBSCRIPTION

A yearly subscription at a rate of $12.00 is available to those who are not members of the Ford Amateur Astronomy Club. Subscription are free to any other astronomy clubs wishing to participate in a newsletter exchange.

APRIL 1996

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20 Astronomy Day
21	22	23	24	25 FAAC Meeting	26	27
28	29	30				

Apr 01 Chiron Closest Approach to Earth (7.457 AU)
Apr 02 Kuiper Belt Object 1994 JR1 Occults 10.7 Magnitude Star
Apr 03 Full Moon (6:39 pm)
Apr 03-04 Lunar Eclipse
Apr 05 Comet Hale-Bopp's Closest Approach to Jupiter (0.7711 AU)
Apr 07 Daylight Savings, Set Clock Ahead One Hour (USA)
Apr 08 Moon Passes 1 Degree South of Asteroid Ceres
Apr 08 Trojan Asteroid 617 Patroclus Occults 7.3 Magnitude Star
Apr 10 Last Quarter Moon (6:06 pm)
Apr 11 Asteroid Harmonia at Opposition
Apr 11 Comet C/1996 B2 (Hyakutake) Near-Venus Flyby (0.23 AU)
Apr 17 New Moon (5:21 pm)
Apr 17 Partial Solar Eclipse, Visible from New Zealand
Apr 18 Asteroid Pallas at Opposition
Apr 20 Astronomy Day
Apr 20 Lyrids Meteor Shower
Apr 22 Mercury At Its Greatest Elongation (20 Degrees)
Apr 24 Comet Mueller 1 Perihelion(2.74 AU)
Apr 25 First Quarter Moon (3:12 pm)
Apr 28 Asteroid Flora at Opposition

MEETING ANNOUNCEMENT

The Ford Amateur Astronomy Club (FAAC) holds regular general meetings on the fourth Thursday of each month, except November and December. Our next meeting will be **Thursday, April 25, at 5:00 pm.** The program for the meeting has not been determined at this time.

The FAAC meets in the Ford Motor Credit Company (FMCC) building, conference room 1491, located on the lower east side of the building. FMCC is the low building immediately northeast of (but not attached to) Ford World Headquarters in Dearborn. The FMCC building is secured with a card entry system. The easiest way to enter the building for meetings is to park in the northeast lot (Employee Lot 7) and enter through the lower northeast or lower east doors. At 5:00 pm no one seems to have trouble getting in because many people are leaving around that time. At the east door you can dial 0911 on the security phone and say you are here to attend a Ford club meeting, and security will admit you. You may find your way into the building any way you see fit, but direction signs will only be posted at lower northeast and lower east doors. ☆

MEETING MINUTES 2/22/96

by Don Klaser

[Sorry about the late minutes, ED.]

The meeting was called to order by president Bob MacFarland at 5:10 pm. Bob recognized last years administration, thanking them for their efforts, and mentioned other people who are interested in our club in Arizona and the Czech Republic. Kevan Granat gave the treasurers report.

Barry Craig spoke about the Star Party being planned for the middle of may up in the thumb area (Huron County). Barry will be in contact with the owners of the campground to confirm; there is interest in both the Detroit and Warren clubs as well as ours. Barry also suggested the idea of giving a basic astronomy talk/program like the one we gave at Lake Erie metro Park. The date for the 4th annual Island Lake Star Party was announced - it will be on Saturday, September 7, the weekend after Labor Day. Also, the dates for the Apollo Rendezvous Star Party in Dayton, Ohio will be June 14 and 15.

Don Klaser spoke about the PR committee; the next meeting will be held on Thursday, March 7 at 5:00 pm in the Body & engineering Building. Chuck Boren announced that the next meeting of the telescope building group will be at George Korody's house on Saturday, March 9 at 1:00 pm. the topic will be estimating the cost to build a scope. Chuck also passed out some information on Comet Hyakutake. Barry Craig spoke about the Detroit club's plan concerning the comet's arrival, including videotaping the comet through a telescope, as well as having information for the print and broadcast media.

Judy Doelker spoke about the Grand Traverse Astronomical Society - their viewing site and the telescope at Northwestern Michigan College. She also passed out literature on the Joseph Roger Observatory at NMC, a viewing schedule for 1996 and copies of the GTAS newsletter.

After the meal break, Bob lead introductions around the table. He asked how many people were interested in a membership list that included names, phone numbers, equipment, and observing interest; almost all raised their hand. Doug Bock announced a deep sky observing session at his house in Fenton on Saturday, February 24, rain or shine. Barry Craig then gave a presentation on CCD imaging. The meeting was adjourned at 6:55 pm. ☆

MEETING MINUTES 3/28/96

by Harry A. Kindt , Sec'y FAAC, (73521.1710@compuserve.com)

The meeting was called to order a 5:10pm by our president Bob MacFarland. There were 35 members and guests present. Bob reported on efforts to improve the methods used to contact our membership in order to inform them of club activities. To this end, a new "Calendar of Events" has been developed which outlines the scheduled events for the year, sponsored by our club and other astronomy clubs in the region. The treasurers report was read and accepted.

Don Klaser reported on the activity of the Education/Public Relations committee. The committee is looking for new members and some new ideas. If you think you would be interested in this aspect of the clubs' activity, please contact Bob or Don for further information. George Korody reported on the progress of the telescope building group which meets at his home on a regular basis. George said that there eight people at the last meeting, either in the process of building a telescope, or who were interested in the process.

Kevan Granat reported on the development of a new "Equipment & Interests Survey". The purpose of the survey is to facilitate communications amongst the membership regarding, equipment, viewing habits and preferences, astronomy software etc.etc. "This survey is an attempt to open lines of communications so that one's valuable experience can benefit others". The members are encouraged to complete the questionnaire and return it to the address on the survey.

The next order of business was a round table discussion. Each member present was asked to give a short talk on some of their recent viewing experiences. Everyone was asked to participate and, as expected, the hot topic of conversation was the recently discovered comet Hyakutake.

Barry Craig reported on the progress of our plans for a multi-club, public star party on May 17-18 at the Justin's Family Campground near Bad Axe MI. As always, we can use any help you may wish to provide in our efforts to make this an "event to remember". If you wish to help out, please contact any of the club officers.

The remainder of the meeting was taken up by a showing of a segment of the "Cosmos" series hosted by Carl Sagan, entitled "Backbone of Night". Meeting was adjourned at 7:00pm. ☆

HOME-BUILT TELESCOPE SIG

from Chuck Boren III

The next meeting of our home built telescope sig will be on April 20 1996 at George's home at 1:00 pm. At this meeting we need to decide what parts we need to buy for the size of scope you are building. Also if you have already bought a mirror and wish to have it checked please bring it to the meeting. If you have any questions you can reach me at 24-83446 or profs me (cboren). My internet address is cboren@delphi.com. ☆

APRIL 1996 SPACE EVENTS

The following April 1996 events come from the 2/25/96 edition of "Space Calendar." This calendar is compiled and maintained by Ron Baalke (baalke@kelvin.jpl.nasa.gov). Note that launch dates are subject to change.

Apr ??	MSAT-1 Ariane 4 Launch
Apr ??	Italsat-2/Amos-1 Ariane 4 Launch
Apr ??	US Air Force Titan 4 Launch
Apr ??	MSX Delta 2 Launch
Apr 01	Progress M-31 Launch (Russia)
Apr 03	Inmarsat 3 Atlas IIA Launch
Apr 15	MISTI-3 Pegasus XL Launch
Apr 15	Priroda Proton Launch (Russia)
Apr 19	Galaxy 9 Delta Launch
Apr 30	SAX (X-ray Astronomy Satellite) Atlas Launch

☆

1996 FAAC CALENDAR OF EVENTS

from Bob MacFarland (bmacfarl)

April 4	Astronomy Day
April 25	F.A.A.C. General Membership Meeting
April 27	Oakland Astronomy Club Spring Star Party Ind. Oaks Nature Center (Mike Bennett 810-651-799)
May 17-18	Detroit Area Club Camping Star Party Pidgeon, MI Public Star Party - Friday Club Observing - Saturday
May 23	F.A.A.C. General Membership Meeting
June 22	F.A.A.C Mini-Star Party Island Lake Recreation Area Brighton, MI
June 27	F.A.A.C. General Membership Meeting
July 14-15	Apollo Rendezvous Dayton Museum of Natural Science Dayton, OH
July 25	F.A.A.C. General Membership Meeting
July 27-30	S.M.U.R.F.S. Star Party (South. Mich. Universal Regional Festival of Stargazers) Festival Genesee Astronomical Society (Richard Walker 810-653-7088) Hillman, MI Observing, Swap, Golf, Camping
September 7	4th Annual F.A.A.C. Star Party Island Lake Recreation Area Brighton, MI
October 19	F.A.A.C. Mini-Star Party Island Lake Recreation Area

☆

ASTRO LINGO

from the following items are from the "Purchasing Amateur Telescope FAQ" by Slc.dennis Bishop (slc.dennis.bishop@muskrat.com)

Chromatic Aberration:
In refractor telescopes, which use lenses to bend the light, different wavelengths of light bend at different angles. This means that the stars you see will usually have a blue/violet ring around them, as this light is bent more than the rest of the spectrum. It is not present at all in reflectors, nor to any significant degree in catadioptrics. Different glasses and crystals (notably fluorite) are sometimes used to compensate for the aberration. Such telescopes are termed "achromat," or "apochromat" if the correction is is nearly perfect.

Collimation:
This refers to how correctly the optics are pointing towards each other. If a telescope is out of collimation, you will not get as clear an image as you should. Refractors generally haved fixed optics, so you don't have to collimate them. Reflectors and catadioptrics usually have screws that you turn to collimate. (This only takes a few minutes to do--it is dead easy).

Coma:
This refers to the blurring of objects at the edge of the field of view, most common in short focal ratio Newtonian telescopes (at f/10 and longer, Newtonians are very well corrected for coma).

Focal Plane:
The plane that the telescope (or eyepiece) focuses on. When you turn the focus knob on the telescope, you are moving the eyepiece back and forth until you make the two focal planes coincide.

Spherical Aberration:
A problem where a lens or mirror in a telescope is not shaped correctly, so the light from the center is focused at a different location than the light from the edges. You should never have to worry about this. This only shows up in really cheap telescopes. ☆

ASTRONOMY BOOK REVIEW

by Sam Wormley (swormley@cnde.iastate.edu) via sci.astro.amateur

POETRY OF THE UNIVERSE: A Mathematical Exploration of the Cosmos
by Robert Osserman
Anchor Books - Doubleday, New York 1995

"On April 24, 1992, newspapers around the world reported an event that was hailed as "one of the major discoveries of the century"—what some would call "the missing link" and "the Holy Grail" of cosmology. The discovery was presented in the form of a picture that was in essence a snapshot of the universe at a dramatic moment in its evolution—the moment that space began. Before the time of the picture, there was only a conglomeration of elementary particles in a state of continual creation and annihilation. Then electrons and protons combined to form atoms of matter. For the first time there was space between the atoms, allowing light and other forms of radiation to travel freely. The "snapshot" depicts the pattern of rays that have reached us after traveling through space from that moment to the present.

What was electrifying to scientists who had been studying those rays—the so-called cosmic microwave background radiation—was that there was a pattern in the picture. After decades of frustration at trying to detect even a ripple of variation in the apparently featureless sea of background radiation, they were now successful in finding a possible link between the undifferentiated primeval "soup" predicted by the big bang theory of creation of the universe and the later evolution into the highly differentiated stars and galaxies of the universe as we know it today.

"Reporters attempting to explain the precise nature of the picture were faced with a least one insurmountable obstacle: neither they nor their readers were prepared for the paradoxical nature of an image that depicts simultaneously a view outward in all directions from the earth and inward in all directions toward the big bang". Osserman's delightful and compelling narrative chart the evolution of ideas in mathematics that have helped to illuminate the nature of the observable universe. He, without equations and with a few figures explores, in an intimate and anecdotal fashion, the leaps of imagination and vision in mathematics that helped pioneer our understanding of the world around us.

OBSERVING HANDBOOK AND CATALOG OF DEEP-SKY OBJECTS
by Christian B. Luginbuhl and Brian Skiff
Cambridge University Press, NY 1990

This book grew out of a lack of a comprehensive modern manual to aid in observing deep-sky objects. The authors began by undertaking a systematic program of visual observations, the aim being to observe each of approximately 1500 galaxies, star clusters and nebulae through three telescopic apertures commonly used by amateur astronomers. As observing proceeded, data was collected on each object from a wide variety of sources, mostly reference catalogues and scientific papers in the professional literature. Accurate total magnitudes were newly derived for open clusters and planetary nebulae. Further, each object was examined after observation on at least one of three photographic sky atlases or on large-scale telescopic photographs to ensure the authenticity of details the authors recorded visually.

Consequently, what is presented is not merely a list of visual observations, but a compendium of information relevant to viewing the brightest deep-sky objects. Included are dimensions, magnitudes, orientations, and angular distances, verified in nearly all cases through photography, photometry, or astrometry. Of the 88 constellations in the sky, 68 north of dec. -50° are encompassed by the survey. The 2050 objects included range from those best viewed in binoculars and small telescopes, such as the Pleiades, to 15th magnitude galaxies. There is catalog of 2828 deep-sky objects and a catalog of 152 double and multiple stars, including 39 intended as aids for gauging seeing. ☆

WHAT TO EXPECT IN TELESCOPE PERFORMANCE

by Don Leuty (dleuty@onramp.net) via sci.astro.amateur

	MAGNIFICATION								LIGHT		RESOLUTION	
Objective Diameter	3.5x per inch	6x per inch	10x per inch	20x per inch	30x per inch	40x per inch	50x per inch	60x per inch	Compara. Scale	Faintest Star	Dawes' Limit	Working Value
1"	3.5x	6x	10x	20x	30x	40x	50x	60x	9 eyes	8.8 mag	4.5 sec	8.0 sec
1 1/4"	4.5x	7.5x	12x	25x	38x	50x	62x	75x	14	9.3	3.6	6.4
1 1/2"	5x	9x	15x	30x	45x	60x	75x	90x	20	9.7	3.0	5.3
1 3/4"	6x	10.5x	17x	35x	52x	70x	87x	105x	28	10.0	2.6	4.6
2"	7x	12x	20x	40x	60x	80x	100x	120x	36	10.3	2.3	4.0
2 1/2"	9x	15x	25x	50x	75x	100x	125x	150x	56	10.8	1.8	3.2
3"	10.5x	18x	30x	60x	90x	120x	150x	180x	81	11.2	1.5	2.7
4"	14x	24x	40x	80x	120x	160x	200x	240x	144	11.8	1.1	2.0
5"	18x	30x	50x	100x	150x	200x	250x	300x	225	12.3	0.9	1.6
6"	21x	36x	60x	120x	180x	240x	300x	360x	324	12.7	0.8	1.3
8"	28x	48x	80x	160x	240x	320x	400x	480x	576	13.3	0.6	1.0
10"	35x	60x	100x	200x	300x	400x	500x	600x	900	13.8	0.5	0.8
Remarks	Lowest useful power ... gives 7mm exit pupil	Best visual acuity ... 4mm exit pupil	Ideal for land objects and wide views of sky	Good for planets, M-objects and general viewing	30 to 40 x per inch is normal hi-power. Use for planet detail, double stars, etc.		Max useful hi-power ... 1/2 mm exit pupil	Useful only for close double stars	Based on dark-adapted unaided eye = 1	Based on ability of naked eye to see mag 6.2 star	Needs "good seeing" and power of ≥ 50x per inch	Based on average seeing. Needs ≥ 30x per inch

If your telescope has good optics, is in good alignment, and if seeing conditions are good, then you can expect performance to the values given in the above table. The critical item being resolving. So far as light grasp and magnification are concerned, even the cheapest, poorest telescope will measure up to standard. The catch, of course, is that light power and magnifying power mean nothing if the telescope image lacks clarity and sharpness.

Light Power: Objective diameter alone determines the light gathering power of a telescope. The bigger the lens or mirror, the more light it'll pick up. The diameter of the human eye's lens is about a 1/3 inch. On the chart, this is given a value of 1. The basis for the faintest star is the magnitude that the eye can see unaided. This is generally accepted to be magnituded 6.2. Any departure from this base should be added or subtracted. For example, if you are only able to see stars to the 5th magnitude, you are 1.2 magnitudes under the base figure and must deduct this amount from the given values. The telescope lets you see all stars brighter. With a 3-inch telescope, an 11th magnitude star will appear as bright as a 6th magnitude start viewed with the unaided eye. This is true of all so-called, "point" sources. All extended objects, i.e, the Moon, planets, nebulae, appear less bright in the telescope than with eyes alone. The same amount of light is now diluted by being spread over the much greated area of the magnified image.

Stars are not magnified: A star has a very small angular diameter. Even the giants and supergiants subtend, at most 0.05 arcseconds. Although stars are too small in angular size to be seen, they are too bright to be ignored. The light-receiving cones and rods in your eyes can be actuated by any light beam, even though the beam itself may only light a small portion of one cone. Hence, one star can trigger a light cone, and the brain gets the same impression as if the cone were fully illuminated.

The Diffraction Pattern: Diffraction is an optical effect caused by the interference of light waves passing around or through an opening. A point object is seen as a tiny disk, surrounded by one or more faint rings of light. About 85% of the light is in the central disk. This is the part you see. The diffraction disk is still very small, but is substantiarly bigger than the diameter of the point object. By optical laws, the angular diameter of the diffraction disk is smaller as the size of the lens is increased. The smaller the diffraction disk, the better the resolving power.

Dawes Limit: The common way of rating telescope resolving power is the minimum separation between two stars which yet allows them to be seen as separate points. It does not mean you can see them cleanly separated, but only that you can tell there are two stars. The general theory is that you can tell there are two stars if the edge of one diffraction disk does not extend beyond the center of the other (i.e., Dawes limit is 1/2 the diameter of the diffraction disk). You will get more fun out of double starts by making your minimum double start twice Dawes limit. This will show the two stars just touching. To test the resolution of your telescope, select a double with a separation of twice Dawes limit. Both stars must be about the same magnitude, not too bright (mag. 5-6), and near the zenith. The seeing conditions must also be good. You will need at least 30X per inch magnification. If you can see the stars just touching, the resolution of your scope is equal to the Dawes limit. If the stars overlap, but are recognizable, you are doing well although not to the Dawes limit. If you see only one star, then, the seeing is bad or your optics are under par.

Detail In Extended Objects: When you look at any extended object, the telescope image is an arrangement of many diffraction disks of a size and spacing determined by the objective diameter. The smaller the disks, the more detail you can see. This is similar to the way more detail is visible in a fine-screen magazine half-tone than in a coarse newspaper half-tone. When the telescope image is magnified 13X per inch of objective diameter, the diffraction pattern becomes equal to the resolving power of the eye. This is equivalent to a 150-line halftone screen. Such a pattern readily allows about 2.5X magnification in order to produce a larger picture, yet not make the pattern too prominent. This is about the effect at 32X per inch magnification (the ideal high power). Definition remains good to about 50X per inch, then deteriorates sharply. At 60X, the diffraction pattern has a structure of about 25 lines per inch. Being a picture painted with light disks, you can't view a telescope image and actually count off this structure. However, the effect of the too-coarse screen is readily apparent. The picture becomes soft and woolly like a photograph with too much enlargement. Remember: You can use all the power you like when looking at single stars or double stars or open clusters, because you are at discrete diffraction disks. However, when you look at extended objects, you want to see the picture as a whole without making the disks of light which comprise it too prominent.

Good Seeing: High power magnifies everything! You've already seen how it magnifies the diffraction pattern to the point of producing a fuzzy image. It also magnifies heat waves, dust clouds, and air currents. All of these things cause poor imagery. Air currents most of all. You have to slice your way through ten miles or more of swirls, up and downdrafts, cold air, and hot spots. When the air is steady, then "seeing is good" and star images shrink to tiny points. A light breeze is often helpful. Good seeing often occurs when the sky is dull and hazy. When you see star images 3 or 4 times normal size, maybe wandering all over the field of the eyepiece, then you know seeing is bad. Since the average backyard astronomer uses modest equipment at 50x to 150x, good seeing is not the problem it is to the professional observer. Although there are times when even a 50X image gets the shakes, you will not be long at observing the Moon until you notice this. Like the weather, nothing can be done about. Reducing power and aperture makes the commotion less disturbing. To distinguish between "seeing" and optical quality, test your scope on a near object in quiet air in daylight. A clear, sharp image proves you have good optics.

Telescope Arithmetic: One of first things you learn about telescopes is the magnification is equal to the focal length of the divided by the focal length of the eyepiece. This basic calculation No.1 in the chart below. Like all equations it can be transposed as shown by formulae 2 and 3. No. 2 determines the FL of eyepiece (FE) needed to obtain a certain magnification. No. 3 gives the FL of the objective if M and FE are known. Calculations using the exit pupil are useful for finding the power of a telescope when you know nothing about the instrument. All you have to do is measure the clear diameter of the objective. Then, on a piece of tracing paper, you can see and measure the exit pupil behind the eyepiece. Formula 4 gives the power. A direct-reading magnifier is a handy instrument for the exact diameter of the exit pupil. Calculations involving the true field and apparent field, Nos. 7, 8 and 9, are the ones you will use most in actual observing. The apparent field of any eyepiece is a fixed angle. For example, a certain Kellner eyepiece may have an apparent field of 50 degrees. This is a

(continued on page 6)

(continued from page 2)
of about 100 rich clusters. The velocities were derived from a comparison of the observed wavelengths of absorption and emission lines with their rest wavelengths (the galaxy 'redshifts'). Assuming a particular value of the 'Hubble constant' (the proportionality factor between the velocity of a galaxy and its distance), the distances of the galaxies can then be derived directly from the measured velocities. The new observations approximately double the amount of data available for rich clusters of galaxies.

In combination with earlier data, the ENACS has produced a 'complete' sample of 128 rich Abell clusters in a region centered near the south galactic pole, and comprising about one-fifth of the entire sky. The sample extends out to a cluster distance of almost 1,000 million light-years. The space density of the 128 clusters is constant within the investigated volume, so that this sample is well suited to study, among others, the distribution of cluster masses. For a representative subset of 80 clusters, accurate information on the internal motions of galaxies in the clusters is available.

MOST NEARBY AND RICH ABELL CLUSTERS ARE REAL

In their pioneering work, Abell and his collaborators identified the clusters from visual inspection of photographic plates obtained with the Palomar telescopes. Some concern has frequently been expressed that an important fraction of the rich Abell clusters may not be real, but rather the result of chance superpositions in the sky of several smaller groups of galaxies. However, the data of the ENACS now prove conclusively that 90 percent of the rich, nearby Abell clusters are real: i.e. many of the galaxies observed in each of these clusters are indeed at the same distance and they form a physical entity.

Nevertheless, about one-quarter of the galaxies in the ENACS do not belong to the main clusters and reside in much smaller galaxy groups or are located in the vast space in between. This can be clearly seen in the distribution of the radial velocities in the direction of each of the clusters. When studying this distribution, it must be kept in mind, that the velocities of the galaxies in the clusters contain two components. The first is due to the general expansion of the Universe and depends only on the distance of the cluster; it is therefore the same for all galaxies in the cluster. The other reflects the individual motions of the galaxies within the cluster.

CLUSTER MASSES AND THE MEAN DENSITY OF THE UNIVERSE

The motions of the galaxies within a cluster makes it possible to estimate the total mass of the cluster: the greater the mass, the faster the motions must be in order to prevent the cluster from collapsing. Using the data for the full sample of 128 clusters, the distribution of cluster masses has been derived. This distribution has been compared with predictions based on several models for the formation of large-scale structures in the Universe.

A very important result of the current work is that the observations do not support scenarios which are based on the assumption that the mean density of the Universe is equal to the 'critical' value, i.e. the one which would correspond to a so-called 'flat' Universe. The observed cluster masses are systematically smaller than those predicted in such models. Instead, the observed distribution of cluster masses seems to indicate that the mean density of the Universe is probably only a fairly small fraction of the critical value. This points to the Universe being 'open' and ever-expanding.

CLUSTER FORMATION MAY STILL BE GOING ON

The galaxies observed during the ENACS programme may be divided into two groups on the basis of their optical spectra, those that show clear emission lines and those that do not. The former are almost all late-type galaxies, that is spiral galaxies with ionized gas in their disks which gives rise to the emission lines. It appears that both the distribution within the cluster, as well as the velocities, of the galaxies with emission lines are significantly different from those of the galaxies without emission lines.

It seems that the emission-line galaxies have a tendency to avoid the central regions of their clusters, and their average radial velocities are about 20 percent larger than those of the non-emission galaxies. A plausible interpretation of these results is that a large part of the emission-line galaxies have not yet 'mixed' with the other galaxies, and that they are approaching the central regions of their respective clusters for the first time. This may imply that the formation of at least a good fraction of the nearby, rich clusters is still going on.

If the mean density of the Universe is indeed much smaller than the critical density, as indicated by the cluster masses determined during this survey, then this is a quite unexpected result. One explanation may be that many clusters have only started to form fairly recently. ☆

ESTIMATING COMET MAGNITUDES

by Charles S. Morris (csm@encke.jpl.nasa.gov)

Making accurate magnitude estimates requires practice. The top observers have been observing for many years and understand the different techniques required for different comet morphologies. Once in a while a comet comes along that challenges even the best observers. C/1996 B2 (Hyakutake) is such a comet. This comet will probably become at least one degree in diameter - that is, twice the diameter of the full Moon - and perhaps larger. How can one accurately estimate the comet's total integrated magnitude?

The normal procedure for estimating comet brightness is to compare the comet (either in-focus or out-of-focus — there are several methods) to a defocused star. When a comet is 30' or less in size, it is usually possible to defocus the binoculars sufficiently to estimate the comet's brightness. If the comet is visible to the naked eye and small enough (comet's head is star-like), an in-focus estimate can be made. For larger naked-eye comets, many people can simply remove their glasses or contacts and make a reasonable estimate of the comet's brightness. The problem with this method is that there is no control over the size of the comparison stars. [Some people can actually defocus their eyes. I have tried this...it can be painful and I do not recommend it.] None of these methods will work well when the comet is more than a half degree in diameter. Three possible methodologies are proposed:

Use a Draw Tube Finder: Some low-power finders have draw tube focusing...that is, you pull/push the eyepiece slide to focus. Some of these allow for more defocusing than binoculars or other models of finders.

Build a 1-Power Telescope: Stephen Edberg (JPL) has proposed and built a 1-power scope designed specifically to solve this problem. [I will be testing the prototype on 96 B2 - csm].

Divide and Conquer: If all else fails, divide and conquer. Estimate the comet's total brightness using the following steps:

- Defocus the comet so it has approximately a uniform brightness...This is very important!
- With the comet still defocused, compare the out-of-focus comparison stars with the surface brightness of the comet...the surface brightness should be more or less uniform so pick any part of the comet. The resulting magnitude estimate, m1(partial), is the brightness of a portion of the defocused comet equal to the size of the defocused comparison stars.
- This is the tough part...estimate the number of defocused stars (N) that will fit into the defocused comet. The accuracy of your estimate depends on how well you estimate this number.
- Add up the pieces...This is done using the following formula:

$$m1 = m1(\text{partial}) - 2.5 \log (N)$$

If the m1(partial)=2.4 and the N=4.5, m1 = 2.4 - 2.5 log (4.5) = 2.4 - 1.6 = 0.8. The resulting total magnitude would be 0.8. ☆

(continued from page 5)
fixed value, the same as the focal length is a fixed value. The true field of the telescope equals AF divided by M (formula 8). Formula 7 gives the magnification when AF and TF are known. Suppose you want to look at the Moon, (angular dia. 1/2°) using the highest power which will show the full disk. If your eyepiece has a 50° apparent field, M = 50 / 0.5 = 100x magnification. The same calculation can also be applied to any part of the whole field. Assume you want to look at a double star with separation of 15 seconds of arc. You will learn from experience that if this true field angle can be increased to 10 minutes apparent field, the double will be nicely separated. Formula 7 solves the problem, but you must first convert 10 minutes to 600 seconds. Then, 600 seconds (AF) divided by 15 seconds (TF) equals 40X, the power needed.

formula 1: M=Fo/Fe	formula 2: Fe=Fo/M	formula 3: Fo=M*Fe
formula 4: M=Do/Ep	formula 5: Ep=Do/M	formula 6: Do=M *Ep
formula 7: M=AF/TF	formula 8: TF=AF/M	formula 9: AF=M/ TF
formula 10: f=Fo/Do	formula 11: Do=Fo/f	formula 12: Fo =f/Do

Where:

M = magnification	Do = objective dia.	TF = true field
Fe = eyepiece FL	AF = apparent field	Ep = exit pupil
Fo = objective FL	f = f-ratio	

☆

HUNTING MIRAGES IN THE SOUTH. SKY

PR 04/96 from the European Southern Observatory

One more cosmic mirage has been found with the ESO 3.5-metre New Technology Telescope (NTT). It consists of two images of the same quasar, seen very close to each other in the southern constellation of Hydra (The Water-Snake). Ever since the exciting discovery of the first cosmic mirage was made seventeen years ago, astronomers have been asking how common this strange phenomenon really is.

In most cases we see more than one image of the same celestial object. This effect is due to the bending and focusing of light from distant objects when it passes through the strong gravitational fields of massive galaxies on its way to us. However, from here on the opinions of the specialists diverge. While some believe that this is a very rare event, others disagree and some have even been suggesting that a substantial fraction of the very faint images seen on long exposure photos obtained with large astronomical telescopes may in fact be caused by this effect. If so, they would not be 'real'.

Is it thus conceivable that the distant Universe is just a great mirror cabinet? There is only one way to answer this important question - more and better observations must be obtained. It is in the course of these investigations that the new discovery was made by a group of three European astronomers [1].

COSMIC MIRAGES ARE CAUSED BY GRAVITATIONAL LENSES

The physical principle behind a cosmic mirage is known since 1916 as a consequence of Einstein's General Relativity Theory. The gravitational field of a massive object curves the local geometry of the Universe, so light rays passing close to the object are also curved (in the same way as a 'straight line' on the surface of the Earth is necessarily curved because of the curvature of the Earth's surface).

This effect was first observed by astronomers in 1919 during a total solar eclipse. Accurate positional measurements of stars seen in the dark sky near the eclipsed Sun indicated an apparent displacement in the direction opposite to the Sun, about as much as predicted by the theory. The effect was obviously due to the gravitational attraction of the stellar photons when they passed near the Sun on their way to us. This was a direct confirmation of a new phenomenon and represented a milestone in physics.

In the 1930's, astronomer Fritz Zwicky (1898 - 1974), of Swiss nationality and working at the Mount Wilson Observatory in California, realised that the same effect may also happen far out in space where galaxies and large galaxy clusters may be sufficiently compact and massive to bend the light from even more distant objects. However, it was only five decades later, in 1979, that his ideas were observationally confirmed when the first example of a cosmic mirage was discovered.

In this connection, it is of particular interest, that this gravitational lensing effect may not only result in double or multiple images of the same object, but also that the intensities of these images increase significantly, just as it is the case with an ordinary optical lens. Distant galaxies, galaxy clusters, etc. may thereby act as natural telescopes which allow us to observe objects that would otherwise have been too faint to be detected with currently available telescopes.

HOW TO FIND COSMIC MIRAGES

Several thousand quasars have so far been discovered. Most astronomers believe that they represent the incredibly bright and energetic centres of distant galaxies. Their distances can be estimated by measuring the velocities with which they recede from us. From their apparent brightness measured at the telescope, it is then easy to calculate their 'intrinsic luminosity', that is the amount of energy they actually radiate.

Some quasars emit more energy than others and the most active ones are known as Highly Luminous Quasars (HLQ's). Most of these may indeed be exceedingly luminous, but it is quite likely that some appear to be so luminous, because their images have been subjected to amplification by an intervening gravitational lens. It is for this reason that the search for gravitational lenses, recognisable as such by the presence of multiple images of the quasar, is particularly promising among objects of the HLQ-type.

This is also the background for the astronomers' success with their long-term ESO Key-Programme 'Gravitational Lensing'. It has the declared goal to determine what fraction of Highly Luminous Quasars are actually subject to the lensing effect. The answer to this specific question will not only help us to understand how frequent gravitational lensing really is; of even more importance is its direct relation to the amount of visible and dark matter in the Universe and also to its geometry. The more common cosmic mirages are found to be, the higher is the number of massive objects in the distant Universe and the larger is their combined mass and hence their contribution to the mean density of the Universe.

A NEW DOUBLE QUASAR WITH VERY SMALL ANGULAR SEPARATION

The Highly Luminous Quasar known under the name J03.13 is the seventh extragalactic gravitational lens candidate to be discovered at La Silla [2] since the beginning of this Key-Programme in 1989. The new object has apparent visual magnitude $V = 17.2$ (i.e., it is 30,000 times fainter than what can be seen with the unaided eye) and a measured redshift of 2.545, i.e. the distance is approximately 10 billion light-years [3].

The fact that the image of J03.13 is double was first established with the SUSI camera at the ESO 3.5-metre New Technology Telescope (NTT) in February 1994. This Press Release is accompanied by Press Photo 06/96 which, thanks to the good angular resolution of the NTT and the large dynamical range of SUSI clearly demonstrates this. The separation of the two components (the 'decomposition') was made with an advanced image processing computer programme and the astronomers have described the detailed results in a scientific paper that has just appeared in the professional European journal Astronomy & Astrophysics (Volume 305, pages L9-L12 (1996)).

The two images of J03.13 are separated by just 0.84 arcsecond. They have the same colour and the difference in brightness is 2.1 mag, i.e. the flux ratio is about 7:1. Low dispersion spectroscopy, obtained with the multi-mode instrument EMMI at the NTT has revealed two absorption line systems (at redshifts $z = 2.340$ and $z = 1.085$). This provides evidence that two condensations of matter are located along the line-of-sight to the quasar. All these observations strongly suggest that we do see two distinct images of a single distant quasar via the effect of gravitational lensing.

Still, to be absolutely sure, it is now necessary to obtain spectra of both images of J03.13. This is not easy because of their very small angular separation and is best done with the Hubble Space Telescope. These observations will be performed during the coming months.

STATISTICS OF HIGH LUMINOSITY QUASARS

More than 1000 HLQs have now been observed with the major telescopes at the ESO La Silla Observatory, the Canada-France-Hawaii Telescope on Mauna Kea, the Nordic Optical Telescope at the island of La Palma (Canarian Islands) as well as with the Hubble Space Telescope in orbit around the Earth. About 1 percent of all of these objects have been found to be affected by strong gravitational lensing effects; J03.13 is one of these.

The results inferred from the related statistical studies are quite sensitive to the individual characteristics of the resolved, multiple quasar images, i.e. their angular separation, brightness difference, etc.. In this context, observations of multiple imaged quasars with an angular separation smaller than 1 arcsecond are particularly important and J03.13 is therefore of special interest. The existence of such "tight" images demonstrates that individual, massive elliptical and spiral galaxies at large distances are able to produce detectable lensing effects, and thus that they were already present several billions of years ago.

Another study by the same group of astronomers, based on the characteristics of the doubly imaged quasars J03.13 A&B, Q1208+1011 A&B and Q1009+025 A&B, for which the galaxies which cause the lensing effect have not yet been found, indicates that any population of dark, compact objects with masses in the range of 10e10 - 10e12 solar masses cannot contribute more than 1/100 of the critical density which is necessary to ultimately stop the universal expansion and close the Universe.

NOTES:

[1] The group consists of Jean-Francois Claeskens, Jean Surdej and Marc Remy (Institut d' Astrophysique, Universite de Liege, Belgium); Jean Surdej is also affiliated with the Space Telescope Science Institute, c/o ESA, Baltimore, Maryland.

[2] The other systems are: UM673 A&B, H1413+117 A-D, UM425 A&B, Q1208+1011 A&B, HE1104-1805 A&B and Q1009-025 A&B. In five cases, two images of the same quasar are seen; H1413+117 has no less than four.

[3] Assuming $H0 = 60$ km/s/Mpc and $q0 = 1/2$; 1 billion = 1000 million. ☆

CHANGING FINDINGS ABOUT JUPITER

Scientists continuing to analyze information returned by the Galileo atmospheric probe that plunged into Jupiter last December report more surprises about the giant gas planet.

Most significantly, the ratio of the elements that make up 99 percent of the Jovian atmosphere — helium and hydrogen — now closely matches that found in the Sun, suggesting that Jupiter's bulk composition has not changed since the planet formed several billion years ago. Estimated amounts of key heavy elements such as carbon and sulfur have increased, but minimal organic compounds were detected, and estimates for Jupiter's wind speeds have climbed still higher.

The ratio of helium to hydrogen by mass is key to developing theories of planetary evolution. In the Sun, this value is about 25 percent. During a January 1996 press conference, Galileo probe scientists estimated that this number for Jupiter was 14 percent. More comprehensive analysis of results from the probe's helium abundance detector has raised this estimate for Jupiter to 24 percent. "This increase implies that the amount of helium in the Jovian atmosphere is close to the original amount that Jupiter gathered as it formed from the primitive solar nebula that spawned the planets," according to Galileo probe project scientist Dr. Richard Young of NASA's Ames Research Center. "The revised helium abundance also indicates that gravitational settling of helium toward the interior of Jupiter has not occurred nearly as fast as it apparently has on Saturn, where the approximate helium-to-hydrogen ratio is just six percent," said Young. "This then confirms that Jupiter is much hotter in its interior than its neighbor Saturn, the next largest planet in the Solar System. It also may force scientists to revise their projections for the size of the rocky core believed to exist deep in the center of Jupiter," he said.

The new estimate of the helium-to-hydrogen ratio on Jupiter is supported by analysis of complementary data from the Galileo probe's neutral mass spectrometer. These new helium results are raising related estimates for the abundances of other key compounds, such as methane. Several heavy elements, including carbon, nitrogen and sulfur, are significantly greater in abundance on Jupiter than in the Sun. "This implies that the influx of meteorites and other small bodies into Jupiter over the eons since its formation has played an important role in how Jupiter has evolved," said Young. However, minimal organic compounds were detected, indicating that such complex combinations of carbon and hydrogen are rare on Jupiter and that the chances of finding biological activity on Jupiter similar to that found on Earth are extremely remote.

The strong Jovian atmospheric winds continue to exceed expectations. Wind speed estimates announced in January of up to 330 mph have grown to more than 400 mph. The winds persisted far below the one cloud layer detected, strongly suggesting that heat escaping from deep in the planet's interior drives the winds, rather than solar heating. Since all the outer giant planets exhibit strong winds, scientists hope that understanding Jupiter's winds will lead to important new insights into their unusual meteorology, Young said.

The scientists continue to report that the probe apparently entered Jupiter's atmosphere near the southern edge of a so-called infrared hot spot, which is believed to be a region of reduced clouds. "The probe's nephelometer observed only one distinct cloud layer, and it is tenuous by Earth standards. It is likely to be an ammonium hydrosulfide cloud," said Young. Three distinct cloud layers (an upper layer of ammonia crystals, a middle layer of ammonium hydrosulfide, and a thick bottom layer of water and ice crystals) were expected.

Further analysis of probe data has confirmed the preliminary report that the Jovian atmosphere appears to be relatively dry, with much less water than anticipated on the basis of solar composition and predictions from data sent by the Voyager spacecraft that flew by Jupiter in 1979. These studies predicted a water abundance for the planet of twice the solar level (based on the Sun's oxygen content.) Actual probe measurements now suggest an amount of water less than that of the Sun.

Scientists confirmed that the probe's instruments found much less lightning activity on Jupiter per unit area than on Earth. Lightning on Jupiter was found to be about 1/10th of that found on Earth in an area of the same size. "Although we found much less lightning activity, the individual lightning events are about ten times more energetic than similar events on Earth," Young said. "This is the sort of unique and exciting information that could not have been obtained in any way other than an atmospheric entry probe," Young said. Complete detailed results of the Galileo probe data analysis will be reported in the May 10 issue of Science magazine. ☆

VLA TO STUDY COMET HYAKUTAKE

from Dave Finley (dfinley@nrao.edu), Public Information Officer

Four teams of scientists are preparing to use the National Science Foundation's (NSF) Very Large Array (VLA) radio telescope to study a bright comet making the closest approach to Earth of any comet in more than a decade. On March 25, Comet Hyakutake will pass within 10 million miles of Earth. Discovered on Jan. 30 by Japanese amateur astronomer Yuji Hyakutake, this comet is exciting scientists who expect to learn a great deal from studying it.

"Much of the progress in cometary research comes from the study of the relatively bright comets," said Patrick Palmer of the University of Chicago. Though several comets a year approach close enough to be studied, observations of "typical" comets often are difficult to interpret, Palmer said, because the observations are sparse and the comets relatively faint. "Bright comets solve these problems," he said, because their brightness produces data of high quality and "excite interest so that more research groups make observations."

Researchers will use the NSF's VLA for three principal types of studies. Three of the groups will seek to detect thermal radio emission from the comet. One of these groups also will look for the characteristic radio emission of particular molecules in the comet's coma. A fourth group will use the VLA as a receiver for a powerful radar signal sent from Goldstone, CA, bounced off the comet and returned to Earth. In four days near the comet's closest approach to Earth, more than 36 hours of VLA observing time will be devoted to its study.

Thermally-generated radio emission from the comet will, scientists hope, provide valuable information. Thermal radio emission has been detected from the nucleus of a comet only once before. One team, led by Carey Lisse of the University of Maryland, hopes that variations in the radio brightness of this emission from the nucleus may allow determination of its rotation period. Wilhelm Altenhoff, from Germany, and Bryan Butler, of NRAO in Socorro, will study thermal emission from Hyakutake's coma, trying to learn about the sizes of the particles making up the coma and of the coma itself. In addition, Palmer says, studying the comet's thermal radio emissions helps scientists understand "the heat balance and indirectly, the composition, of comets."

Comet Hyakutake also will be observed at very specific radio wavelengths that indicate the presence of particular molecules, including formaldehyde, methanol and ammonia. Comets, "dirty snowballs" of ices and dust, are believed to be made of material left over from the formation of the planets and moons. As such, they offer scientists an opportunity to learn about the presolar nebula from which the solar system was formed. Radio observations are an important part of this research, because many of the molecules scientists seek to find in comets "are most easily seen and identified at radio wavelengths," Palmer said. "Detection of these molecules is very important to enable us to answer the question of what comets are made of. More than 100 of these molecules have been identified in the spectrum of interstellar gas in star-forming regions. So far, less than 20 have been seen in comets. Is this because of the intrinsic difficulty of observing comets or because something different has happened to the gas that was incorporated into comets when the solar system was formed?"

A research team headed by Imke de Pater of the University of California at Berkeley will use the VLA as the receiving portion of a radar system that will bounce microwave signals off the comet. The California transmitter for this system is operated by NASA's Jet Propulsion Laboratory. Using this radar system, the scientists hope to learn details about a halo of centimeter-sized particles around the nucleus of the comet. Such a halo "has never been directly detected before," de Pater said, but has been inferred.

The radar observations, Palmer added, will help "measure the distribution of centimeter-sized particles around comets." These are the particles that, when their orbital paths cross that of Earth, are seen as bright meteors. Scientists hope to learn what proportion of these particles are large enough to survive atmospheric entry and actually hit the Earth. "This is an important question when considering the source of the meteors that do hit Earth," Palmer said.

Many of the VLA observations are in conjunction with observations by other telescopes, both radio and optical. Astronomers are using a wide variety of ground-based and orbiting telescopes to gain the most possible information about the comet. "No telescope other than the VLA is capable of carrying out either the radar experiment or the detection of long-wave thermal emission," said Lisse. The VLA is an instrument of the National Radio Astronomy Observatory (NRAO). The NRAO is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities. ☆

STATISTICALLY SPEAKING

Location (Dearborn, MI): 42°22'00" N, 83°17'00" W, 180 meters elevation
Local Time = Universal Time - 5.5 hours (Eastern Standard Time)

Abbreviations used in reports:

FM Full Moon	FQ First Qtr Moon	LQ Last Qtr Moon	NM New Moon
MR Moon Rise	MS Moon Set	SR Sun Rise	SS Sun Set

Calendar Report for April 1996

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 SR: 5:45 SS: 18:29 MR: 16:22 MS: 4:25	2 SR: 5:43 SS: 18:31 MR: 17:24 MS: 4:55	3 SR: 5:42 SS: 18:32 MR: 18:28 MS: 5:26	4 SR: 5:40 SS: 18:33 MR: 19:33 MS: 5:59	5 SR: 5:38 SS: 18:34 MR: 20:39 MS: 6:35	6 SR: 5:36 SS: 18:35 MR: 21:45 MS: 7:15
7 SR: 5:35 SS: 18:36 MR: 22:49 MS: 8:00	8 SR: 5:33 SS: 18:37 MR: 23:49 MS: 8:51	9 SR: 5:31 SS: 18:38 MR: None MS: 9:49	10 SR: 5:30 SS: 18:40 MR: 0:43 MS: 10:52	11 SR: 5:28 SS: 18:41 MR: 1:32 MS: 11:58	12 SR: 5:27 SS: 18:42 MR: 2:15 MS: 13:07	13 SR: 5:25 SS: 18:43 MR: 2:54 MS: 14:15
14 SR: 5:23 SS: 18:44 MR: 3:30 MS: 15:24	15 SR: 5:22 SS: 18:45 MR: 4:04 MS: 16:32	16 SR: 5:20 SS: 18:46 MR: 4:37 MS: 17:38	17 SR: 5:18 SS: 18:47 MR: 5:11 MS: 18:44	18 SR: 5:17 SS: 18:49 MR: 5:46 MS: 19:47	19 SR: 5:15 SS: 18:50 MR: 6:24 MS: 20:48	20 SR: 5:14 SS: 18:51 MR: 7:05 MS: 21:44
21 SR: 5:12 SS: 18:52 MR: 7:49 MS: 22:37	22 SR: 5:11 SS: 18:53 MR: 8:36 MS: 23:25	23 SR: 5:09 SS: 18:54 MR: 9:26 MS: None	24 SR: 5:08 SS: 18:55 MR: 10:19 MS: 0:07	25 SR: 5:06 SS: 18:57 MR: 11:14 MS: 0:46	26 SR: 5:05 SS: 18:58 MR: 12:11 MS: 1:21	27 SR: 5:03 SS: 18:59 MR: 13:08 MS: 1:53
28 SR: 5:02 SS: 19:00 MR: 14:08 MS: 2:24	29 SR: 5:01 SS: 19:01 MR: 15:08 MS: 2:54	30 SR: 4:59 SS: 19:02 MR: 16:11 MS: 3:24		Lunar Events FM: 18:39 Apr 03 LQ: 18:06 Apr 10 NM: 17:21 Apr 17 FQ: 15:12 Apr 25		

Lunar Eclipse Report for April 4, 1996

Moon rise:	18:28	Moon set:	5:26
Partial phase begins:	16:54	Total phase begins:	18:00
Total phase ends:	19:25	Partial phase ends:	20:31

Planet View Info Report for April 1996

Date	Rise	Set	RA	Dec	Elongation	Ill Fr	DIST-AU
Mercury							
4/ 1/1996	5:59	[illegible]	[illegible]m52s	5°30'19"	[illegible]°56'44"	0.989	1.31719
4/ 8/1996	5:59	19:42	1h49m44s	11°58'32"	11°18'57"	0.885	1.21906
4/15/1996	5:57	20:23	2h38m01s	17°23'56"	17°20'39"	0.668	1.06478
4/22/1996	5:52	20:45	3h15m57s	20°53'25"	20°09'44"	0.425	0.89078
4/29/1996	5:40	20:41	3h38m25s	22°13'45"	18°45'44"	0.220	0.73515
Venus							
4/ 1/1996	7:28	22:37	3h37m26s	22°43'11"	45°58'00"	0.511	0.71002
4/ 8/1996	7:20	22:46	4h05m29s	24°34'41"	45°47'02"	0.470	0.65552
4/15/1996	7:12	22:52	4h32m15s	26°00'39"	45°09'58"	0.426	0.60104
4/22/1996	7:03	22:54	4h57m01s	27°00'47"	43°59'21"	0.378	0.54703
4/29/1996	6:54	22:50	5h18m45s	27°35'42"	42°04'32"	0.324	0.49414
Mars							
4/ 1/1996	5:37	17:56	0h22m19s	1°32'20"	5°52'21"	0.999	2.38343
4/ 8/1996	5:21	17:56	0h42m09s	3°43'10"	7°20'13"	0.998	2.38465
4/15/1996	5:06	17:56	1h01m57s	5°51'28"	8°48'47"	0.997	2.38530
4/22/1996	4:50	17:56	1h21m48s	7°56'13"	10°18'08"	0.996	2.38522
4/29/1996	4:35	17:56	1h41m42s	9°56'28"	11°48'13"	0.995	2.38434
Jupiter							
4/ 1/1996	1:57	11:07	19h09m07s	-22°21'34"	85°36'33"	0.991	5.21235
4/ 8/1996	1:32	10:42	19h11m50s	-22°17'39"	91°52'16"	0.991	5.09970
4/15/1996	1:06	10:17	19h13m57s	-22°14'37"	98°14'38"	0.991	4.98746
4/22/1996	0:40	9:51	19h15m28s	-22°12'39"	104°44'11"	0.991	4.87700
4/29/1996	0:13	9:24	19h16m20s	-22°11'49"	111°21'01"	0.992	4.76984
Saturn							
4/ 1/1996	5:27	17:15	23h59m11s	-2°18'05"	12°48'42"	1.000	10.54513
4/ 8/1996	5:02	16:52	0h02m18s	-1°58'26"	18°48'20"	1.000	10.51354
4/15/1996	4:36	16:29	0h05m21s	-1°39'22"	24°49'06"	1.000	10.47036
4/22/1996	4:11	16:05	0h08m19s	-1°21'02"	30°50'30"	0.999	10.41602
4/29/1996	3:45	15:42	0h11m10s	-1°03'35"	36°52'26"	0.999	10.35115
Uranus							
4/ 1/1996	3:02	12:34	20h25m52s	-19°47'35"	67°32'59"	0.999	20.12054
4/ 8/1996	2:35	12:08	20h26m40s	-19°45'02"	74°14'48"	0.999	20.00986
4/15/1996	2:08	11:41	20h27m19s	-19°43'01"	80°57'23"	0.999	19.89536
4/22/1996	1:41	11:14	20h27m49s	-19°41'34"	87°40'52"	0.999	19.77864
4/29/1996	1:14	10:47	20h28m08s	-19°40'42"	94°25'04"	0.999	19.66139

Planet/Moon Apsides Report for April 1996

4/ 9/1996	Mercury @ Perihelion	Distance from Sun: 0.31 AU	
4/10/1996	Moon @ Perigee	Hour = 22	Distance from Earth: 369911 km
4/24/1996	Moon @ Apogee	Hour = 17	Distance from Earth: 404377 km

Meteor Showers Report for April 1996

Date	Meteor Shower	ZHR	RA	DEC	Illum. Frac.	Longitude
4/11/1996	Virginids	5	14h04m	-9∞	0.41	22∞
4/21/1996	Lyrids	12	18h08m	32∞	0.15	32∞
4/27/1996	alpha-Scorpiids	5	16h32m	-24∞	0.68	38

☆

SKY & TELESCOPE NEWS BULLETINS

from the editors of SKY & TELESCOPE magazine

A SLOW NOVA

On February 20th, Japan's Yukio Sakurai photographed what appeared to be a new star just northwest of M23 in Sagittarius. A light curve compiled by the VSNET variable-star clearinghouse (http://www.kusastro.kyoto-u.ac.jp/vsnet) shows that a 5-magnitude brightening took place between 1994 and 1995. Spectra and images from late February suggest that the star is undergoing a final helium-shell flash and that it is surrounded by a young planetary nebula. Such events are believed to mark the evolutionary end of low-mass red giants. But only one other star — a 1919 nova in Aquila — has been caught in the act by modern-day astronomers. Designated Nova Sagitarii 1996, the 11th-magnitude star is at right ascension 17h 52m 32s, declination -17 dg 41.1'. Finder charts are posted on the VSNET WWW page noted above.

PULSING X-RAY BURSTER

An X-ray source that both pulses and bursts has been discovered by the Compton Gamma Ray Observatory. Designated J1744-28, this object was discovered last December when Compton's detectors discerned a new source of X-ray bursts somewhere toward our galaxy's center. Transient bursters are nothing new to high-energy astrophysics. However, the sporadic bursts are accompanied by feeble X-ray pulses that arrive 128 times each minute with clocklike regularity. This means that the bursts occur on or near a rapidly rotating, strongly magnetized neutron star, or pulsar. The bursts are presumably fueled by matter drawn from an unseen companion, most likely a low-mass star, that orbits the pulsar every 11.8 days. Bursting and pulsing behavior had never been seen from the same X-ray source before, and the juxtaposition puzzles some theorists. ☆

HYAKUTAKE VIEWING CALENDAR

By Alan MacRobert, SKY & TELESCOPE Magazine

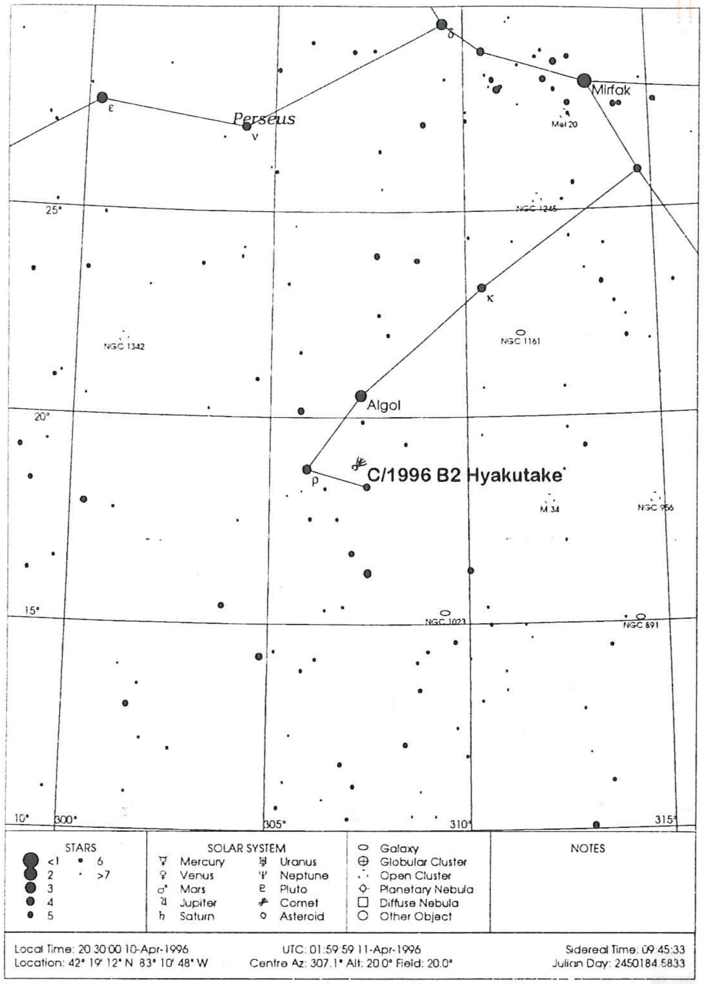
Nobody should miss the chance to see this astronomical marvel! The information here will enable you to find and view the comet for yourself — even if you have no skywatching experience. The first thing to do is find a dark viewing site. To see the comet well — or perhaps at all o you'll need to get away from glary outdoor lights and give your eyes time to adapt to the dark. You may also need to get out from under the milky glow of light pollution that fills the night sky over cities and suburbs and washes out the view of most of the universe.

April 1-4: Although the comet is shrinking and fading, its head and general outline may start becoming more sharply defined, a process that should continue through late April. A comet's tail always points in the direction away from the Sun; currently the Sun is below the west-northwestern horizon at nightfall. This means the tail will extend upward, leaning a little to the right, for the rest of the month. In early April, look about two fist-widths to the lower right of Capella and almost three fist-widths to the right or upper right of Venus (which, incidentally, is next to the Pleiades star cluster; take a look with our binoculars). The modestly bright star near the comet these nights is Alpha Persei, also known as Mirfak.

April 5-12: The sky is now completely free of moonlight shortly after darkness falls. You'll find the comet two fist-widths to the right of Venus, possibly just a little lower depending on the date and your location. The moderately bright (2nd-magnitude) star near the comet's head from April 7th to 11th is Algol, or Beta Persei. During this period the comet should be at its minimum brightness for April.

April 13-28: Scan low in the northwest every clear evening right around the end of twilight. In mid-April the comet is to the lower right of brilliant Venus by about two fist-widths, and in late April by three fist-widths. During this time the comet should brighten again, and the tail may lengthen even as the head becomes more compact. The comet's head will get a little lower to the horizon each day. By late April it will be so low that you'll need a good, open view of the northwestern horizon. You'll also have to look a little before twilight fades away completely. Bring the binoculars!

April 29 and later: The comet swings closest to the Sun (21 million miles) on May 1st, but by then it has become hidden in the Sun's glare. After its solar flyby ("perihelion"), the comet swings rapidly south; it never comes back into view for observers at mid-northern latitudes. Rapidly fading, it becomes an object for Southern Hemisphere astronomers in mid- and late May. By summer it will have faded to telescope-only visibility. ☆



COMET HYAKUTAKE EPHEMERIS

Updated (Mar. 12, 1996) ephemeris with perturbations for Comet 1996 B2 Hyakutake by Don K. Yeomans of JPL. Ephemeris output times are UTC *(subtract 5.5 hours for local Detroit metro-area time).*

Date	Hr	R.A. J2000	Dec.	Delta	Deldot	r	Theta	Beta	Moon	PsAng	TMag
Apr 1	00	3 13 30.3	+54 51 18.8	.24	51.6	.90	58.7	107.9	95	45.5	1.5
Apr 1	06	3 12 53.5	+53 18 49.4	.25	52.0	.89	57.9	108.3	98	45.5	1.5
Apr 2	00	3 11 19.5	+51 56 16.2	.27	52.8	.87	55.7	109.4	107	45.5	1.6
Apr 2	06	3 10 52.5	+51 18 14.4	.28	53.0	.87	55.0	109.6	109	45.5	1.6
Apr 3	00	3 09 40.7	+49 35 14.4	.30	53.5	.85	53.1	110.3	118	45.5	1.7
Apr 3	06	3 09 19.2	+49 04 09.6	.31	53.7	.85	52.5	110.5	121	45.4	1.7
Apr 4	00	3 08 20.5	+47 39 07.1	.33	54.1	.83	50.8	110.9	129	45.4	1.8
Apr 4	06	3 08 02.4	+47 13 11.8	.34	54.2	.82	50.3	111.0	132	45.3	1.8
Apr 5	00	3 07 11.8	+46 01 36.9	.36	54.6	.81	48.8	111.3	140	45.2	1.9
Apr 5	06	3 06 55.8	+45 39 35.8	.37	54.7	.80	48.3	111.3	142	45.2	1.9
Apr 6	00	3 06 10.0	+44 38 17.0	.39	54.9	.78	46.9	111.4	148	45.0	1.9
Apr 6	06	3 05 55.4	+44 19 16.0	.40	55.0	.78	46.4	111.4	149	45.0	2.0
Apr 7	00	3 05 12.5	+43 25 53.8	.43	55.2	.76	45.1	111.3	152	44.7	2.0
Apr 7	06	3 04 58.5	+43 09 12.9	.43	55.3	.75	44.7	111.3	152	44.7	2.0
Apr 8	00	3 04 17.2	+42 22 03.6	.46	55.4	.74	43.4	111.1	149	44.4	2.0
Apr 8	06	3 04 03.5	+42 07 12.8	.47	55.5	.73	43.0	111.0	147	44.3	2.0
Apr 9	00	3 03 22.7	+41 24 57.2	.49	55.6	.71	41.9	110.7	141	44.0	2.0
Apr 9	06	3 03 09.0	+41 11 33.4	.50	55.7	.71	41.5	110.6	138	43.9	2.0
Apr 10	00	3 02 27.9	+40 33 10.1	.52	55.8	.69	40.3	110.1	130	43.5	2.0
Apr 10	06	3 02 14.1	+40 20 55.0	.53	55.9	.68	39.9	110.0	127	43.4	2.0
Apr 11	00	3 01 32.1	+39 45 35.0	.55	56.0	.67	38.8	109.5	118	42.9	2.0
Apr 11	06	3 01 17.9	+39 34 14.0	.56	56.0	.66	38.5	109.3	115	42.8	2.0
Apr 12	00	3 00 34.4	+39 01 17.5	.59	56.2	.64	37.4	108.7	105	42.3	1.9
Apr 12	06	3 00 19.7	+38 50 38.5	.59	56.2	.64	37.0	108.5	102	42.1	1.9
Apr 13	00	2 59 34.4	+38 19 32.3	.62	56.3	.62	35.9	107.8	92	41.6	1.9
Apr 13	06	2 59 19.0	+38 09 25.1	.63	56.4	.61	35.6	107.5	88	41.4	1.9
Apr 14	00	2 58 31.4	+37 39 40.8	.65	56.5	.59	34.5	106.7	78	40.8	1.8
Apr 14	06	2 58 15.2	+37 29 56.6	.66	56.5	.58	34.1	106.4	75	40.6	1.8
Apr 15	00	2 57 25.0	+37 01 09.0	.68	56.7	.57	33.1	105.5	65	40.0	1.7

RA J2000 Dec = Geocentric astrometric right ascension and declination referred to mean equator and J2000 equinox (with light time corrections).
Delta = Geocentric distance of object in AU
Deldot = Geocentric radial velocity of object in km/s
r = Heliocentric distance of object in AU
Theta = Sun-Earth-Object angle in degrees
Beta = Sun-Object-Earth angle in degrees
Moon = Object-Earth-Moon angle in degrees
PsAng = Position angle of extended radius vector in degrees
TMag = Approximate Total magnitude

Ford Amateur Astronomy Club
Star Stuff Newsletter
P.O. Box 7527
Dearborn, MI 48121