Star Stuff

THE FORD AMATEUR ASTRONOMY CLUB NEWSLETTER

Volume 6, Number 3 March 1997

EUROPEAN ASTRONOMER'S SUCCESSES WITH HUBBLE SPACE TELESCOPE

European Space Agency, Press Information Note No. 03-97

European astronomers' successes with the Hubble Space Telescope

Excellent use of Hubble continues to provide astronomers in ESA's member states with a disproportionate share of the space telescope's observing time. ESA has a 15 per cent stake in the Hubble Space Telescope project, earned by providing the Faint Object Camera, the first two sets of solar power arrays, and some staff at the Space Telescope Science Institute in Baltimore. Current European-led programmes account for about 22 per cent of the observing schedule. So what have Europe's astronomers been doing with Hubble? Their work spans all aspects of astronomy, from the planets to the most distant galaxies and quasars, and the following examples are just a few European highlights from Hubble's second phase, 1994-96.

A scarcity of midget stars

Stars less massive and fainter than the Sun are much numerous in the Milky Way Galaxy than the big bright stars that catch the eye. Guido De Marchi and Francesco Paresce of the European Southern Observatory as Garching, Germany, have counted them. With the wide-field WFPC2 camera, they have taken sample censuses within six globular clusters, which are large gatherings of stars orbiting independently in the Galaxy. In every case they find that the commonest stars have an output of light that is only one-hundredth of the Sun's. They are ten times more numerous than stars like the Sun.

More significant for theories of the Universe is a scarcity of very faint stars. Some astronomers have suggested that vast numbers of such stars could account for the mysterious dark matter, which makes stars and galaxies move about more rapidly than expected from the mass of visible matter. But that would require an ever-growing count of objects at low brightnesses, and De Marchi and Paresce find the opposite to be the case — the numbers diminish. There may be a minimum size below which Nature finds starmaking difficult. The few examples of very small stars seen so far by astronomers may be, not the heralds of a multitude of dark-matter stars, but rareties.

Unchanging habits in starmaking

Confirmation that very small stars are scarce comes from Gerry Gilmore of the Institute of Astronomy in Cambridge (UK). He leads a European team that analyses long-exposure images in the WFPC2 camera, obtained as a by-product when another instrument is examining a selected object. The result is an almost random sample of well-observed stars and galaxies. The most remarkable general conclusion is that the make-up of stellar populations never seems to vary. In dense or diffuse regions, in very young or very old agglomerations, in the Milky Way Galaxy or elsewhere, the relative numbers of stars of different masses are always roughly the same. Evidently Nature mass-produces quotas of large and small stars irrespective of circumstances. This discovery will assist astronomers in making sense of very distant and early galaxies. They can assume that the stars are of the most familiar kinds.

Another surprise was spotted by Rebecca Elson in Gilmore's team, in long-exposure images of the giant galaxy M87, in the nearby Virgo cluster. It possesses globular clusters of very different ages. In the Milky Way and its similar spiral neighbour, the Andromeda galaxy, globular clusters contain the oldest stars. While M87 has ancient globular clusters too, some are different in colour and much younger. The theory is that they were manufactured during collisions of the galaxies that merged into M87, making it the egg-shaped giant seen today. If so, the absence of young globular clusters in the Milky Way may mean that our Galaxy has never suffered a major collision.

Accidents in the galactic traffic

Brighter than a million million suns, a quasar is the most powerful lamp in the Universe. Astronomers understand it to be powered by matter falling into a massive black hole in the heart of a galaxy. Mike Disney of the University of Wales, Cardiff, leads a European team that asks why some thousands of galaxies harbour quasars, in contrast to the billions that do not. In almost every case that he and his colleagues investigated, using Hubble's WFPC2 at its highest resolution, they see the quasar's home galaxy involved in a collision with another galaxy. "It's my opinion that almost any galaxy can be a quasar," Disney says, "if only its central black hole gets enough to eat. In the galactic traffic accidents that Hubble reveals, we can visualize fresh supplies of stars and gas being driven into the black hole's clutches. My American opposite number, John Bahcall, prefers to stress those quasar hosts that look like undisturbed galaxies. But the important thing is that we have wonderfully clear pictures to argue about. Quasar theories were mostly pure speculation before we had Hubble."

The history of the elements

Astronomers at the Hamburger Sternwarte use the Faint Object Spectrograph to analyse ultraviolet light from distant quasars, which they also examine by visible light from the ground. They trace the origin, through cosmic time, of elements like carbon, silicon and iron, from which planets and living things can be built. On its way to Hubble, the quasar light passes through various intervening galaxies and gas clouds, like the skewer of a kebab. Each object visited absorbs some of the quasar light, depending on the local abundances of the elements. As they detect more and more objects, Dieter Reimers and his colleagues form an impression of galaxies building up their stocks of elements progressively through time, by the alchemy of successive generations of stars.

Apart from primordial hydrogen the second lightest element, helium, has also been abundant since the origin of the Universe. The first major discovery after Hubble's last refurbishment came from Peter Jakobsen of ESA's Space Science Department at Noordwijk, who detected ionized helium in the remote Universe, by the light of a very distant quasar, 0302-003. That was in January 1994, and since then Jakobsen has looked for the ionized helium using other quasars. He now suspects that this helium is nearly all gathered in clumps, rather than scattered freely through intergalactic space. If so, it greatly increases the estimates of the total mass of ordinary matter in the Universe.

Through a lens to the early Universe

Natural lenses scattered through the cosmos reveal distant galaxies, and make an astronomical tool for Richard Ellis of the Institute of Astronomy, Cambridge (UK). The strong gravity of an intervening cluster of galaxies can bend the light from more distant objects, so magnifying and intensifying their images. In one spectacular case, cluster Abell 2218 creates in Hubble's WFPC2 camera more than a hundred images of galaxies lying beyond it. Without the magnifying effect of the cluster, many of these remote objects would be too faint to study in detail. Compared with man-made optics, the gravitational lenses are complex. They produce multiple images (as many as seven or more) and they also smear the images into arcs. Team-member Jean-Paul Kneib, who is now at Toulouse, uses the distortions as a guide to distance. The more distorted the image, the farther off a galaxy is. The galaxies imaged by Abell 2218 are 5 to 8 billion light-years away, and Kneib's estimates have been confirmed by Tim Ebbels of Cambridge using the William Herschel Telescope located on the Spanish island of La Palma. Seen as they were early in the history of the Universe, the objects seem surprisingly similar to nearer and more mature galaxies.

(continued on page 2)

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The cosmic scale

Gustav Tammann of Basel and his collaborators use the Hubble Space Telescope to measure the Hubble Constant. Both are named after Edwin Hubble who discovered, almost 70 years ago, that the galaxies are spreading apart. The Hubble Constant is the rate of expansion — and the most important number in cosmology, because it fixes the size and the maximum age of the observable Universe. Since the launch of the space telescope in 1990, two independent teams have tried to fix the constant but their answers disagree. A high expansion rate, which makes the Universe relatively young, is preferred by Wendy Freedman's team consisting largely of American astronomers. A lower value for Hubble's Constant, implying an older Universe, comes from a mainly European team led by the American astronomer Allan Sandage. Tammann belongs to the latter, "old Universe" camp and he is philosophical about the delay in reaching a consensus.

"I've been waiting nearly 20 years for this result, and I expect the arguments will go on for a while longer," Gustav Tammann says. "In 1979 I asserted that a key task for the space telescope should be to use variable stars to fix the distances to nearby galaxies in which standard supernovae have been seen. Then the supernovae become candles lighting our way far out into the Universe. Well we've done it now, with stars in seven galaxies, and their supernovae give us wonderfully consistent answers. So we're in no mood to compromise, or to split the difference with Wendy Freedman's Hubble Constant. Time will tell us who is closer to the right answer." ☆

PHYSICS NEWS UPDATE

The American Institute of Physics Bulletin of Physics News (physnews@aip.org) by Phillip F. Schewe and Ben Stein

A BLACK HOLE'S EVENT HORIZON HAS BEEN DETECTED. Ramesh Naryan and his colleagues at the Harvard- Smithsonian Center for Astrophysics have used the orbiting ASCA x-ray telescope to study x-ray novas, binary systems in which gas from one star is pulled toward an accretion disk and the spherical region surrounding a compact companion. These systems occasionally flash prominently at x-ray wavelengths (hence the name x-ray nova), but Naryan is more interested in what happens during the quiescent intervals between upheavals. His recent theory, called the advection-dominated accretion flow (ADAF) model, suggests that if the accretion rate is slow enough the inspiraling gas will refrain from radiating away its accumulating energy. Instead the gas continues to get ever hotter, reaching temperatures as high as 10^12 K. Eventually this enormous energy buildup is dealt with in one of two ways: if the compact object is a neutron star, the gas will fall onto its surface, where it heats the star, causing it to radiate. In contrast, if the object is a black hole, there is no surface for the gas to fall upon; instead, like a prisoner being led to execution, the gas crosses the black hole's event horizon, never to be seen again. In effect, 99% of the gas energy disappears from the universe. Because of this, x-ray binaries containing a black hole should be dimmer than those with neutron stars. Naryan, speaking at a meeting of the American Astronomical Society in Toronto, reported on 9 binaries which fit the ADAF pattern of behavior. Four of these were thought to harbor black holes (because of their higher masses), and indeed these are all dimmer than the five neutron-star binaries. Naryan judges this dimness, and the binaries' x-ray spectra, to be the sign that an event horizon is at work, and that this in turn constitutes the most direct evidence yet for the existence of black holes.

OUR LOCAL CLUSTER OF GALAXIES IS STILL FORMING. For decades astronomers have wondered about the origin of certain fast-moving clouds of atomic hydrogen in the vicinity of the Milky Way. In some cases the clouds appeared to be plunging into the plane of the galaxy (at speeds as large as 500 km/sec), and could not be considered as rotating with the galaxy. Later observations showed that some clouds actually seemed to be moving away from the Milky Way. A synthesis of new radio- telescope measurements plus re-evaluated data from COBE and the Hubble Space Telescope indicates that the clouds may be raw material left over from the formation of the entity known as the Local Group of galaxies, whose largest shareholders are the Andromeda galaxy (with 65% of the mass of the group) and our own Milky Way (30%). Reporting at a American Astronomical Society meeting in Toronto, Leo Blitz of UC Berkeley and David Spergel of Princeton said that the high velocity clouds will continue of feed the Milky Way (providing fuel for future star formation) and might even harbor dark matter, a hypothesis which would account for the continued stability of the clouds and their unexplained large internal velocities. Spergel said that the features of his theory for nearby high velocity clouds might apply also to larger, more distant hydrogen clouds in the cosmos. ☆

STAR STUFF
Monthly Publication of the Ford Amateur Astronomy Club

Star Stuff Newsletter
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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.

WWW PAGE

Computers inside the Ford network or on the Internet can access the F.A.A.C. web page at one of the following addresses:

Ford Intranet:	http://pt0106.pto.ford.com/faac/faac.html
Internet:	http://kode.net/~dougbock/faac/

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

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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. Subscriptions are free to other astronomy clubs wishing to participate in a newsletter exchange.

MARCH 1997

SUN	MON	TUE	WED	THU	FRI	SAT
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27 FAAC Meeting	28	29
30	31					

Mar 01 Asteroid 139 Juewa at Opposition (10.5 Magnitude)
Mar 01 Comet 1997 B1 Kobayashi at Perihelion (2.062 AU)
Mar 02 Last Quarter Moon (4:38 am)
Mar 02 Mercury Passes 0.8 Degrees from Venus
Mar 02 Asteroid 16 Psyche at Opposition (10.3 Magnitude)
Mar 02 Asteroid 71 Niobe at Opposition (10.5 Magnitude)
Mar 04 Comet Hale-Bopp Directly Above The Sun (1.04 AU)
Mar 08 New Moon (8:16 pm)
Mar 09 Solar Eclipse, Visible from Russia, Arctic
Mar 09 Comet Hale-Bopp Crosses Over Earth's Orbit
Mar 10 Asteroid 1990VA Near-Earth Flyby (0.2069 AU)
Mar 11 Asteroid 6 Hebe at Opposition (9.6 Magnitude)
Mar 11 Asteroid 18 Melpomente at Opposition (10.1 Magnitude)
Mar 13 Summer Solstice on Mars
Mar 14 Comet Hale-Bopp Occults PPM 63645 (10.9 Magnitude Star)
Mar 14 Comet Wirtanen Perihelion (1.065 AU)
Mar 14 Moon Occults Aldebaran
Feb 15 First Quarter Moon (7:07 pm)
Mar 17 Mars at Opposition
Mar 18 Asteroid 1275 Cimbria Occults PPM 720568 (9.9 Magnitude Star)
Mar 20 Comet Schwasmann-Wachmann 2 Near-Jupiter Flyby (0.246 AU)
Mar 20 Vernal Equinox (8:56 am)
Mar 20 Mercury Passes 1.9 Degrees From Saturn
Mar 21 Asteroid 377 Campania Occults SAO 138801 (8.4 Magn. Star)
Mar 22 Comet Hale-Bopp Closest Approach to Earth (1.315 AU)
Feb 23 Full Moon (11:46 pm)
Mar 23 Asteroid 732 Tjilaki Occults PPM 232217 (9.3 Magnitude Star)
Mar 24 Partial Lunar Eclipse
Mar 26 Comet Helin-Roman-Alu 1 Perihelion (3.715 AU)
Mar 30 Last Quarter Moon (2:38 pm)
Mar 31 Venus Passes 0.9 Degrees from Saturn ☆

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, March 27, at 5:00 pm.** The agenda is usually distributed electronically a couple days before the meeting.

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. ☆

2/27/97 FAAC MEETING MINUTES

by Harry Kindt, Sec'y F.A.A.C.

The regularly scheduled meeting of the Ford Amateur Astronomy Club was called to order at 5:00 PM by our president Bob MacFarland. There were 38 members and guests present. Bob welcomed the new members and guests who were in attendance. The treasurers report was read and accepted. Ray Fowler, our new treasurer, suggested, due to the election of new club officer's, and as a matter of good business practice, that an audit be made of the club's finances. We are looking into this matter, and the executive committee will keep you informed of the results.

Bob MacFarland reported on the new web site for the FERA organization. For those of you with web access the address is http://www.fera.org. Doug Bock reported on the several events he has planned for the upcoming months. On March 8th, there will be a Deep Sky Meeting and a "photon acquisition " party at his Northern Cross Observatory. On May 9-10-11, Doug will be hosting a star party at his property just West of Cadillac, MI. On the 6-7-8 of June, Doug will be hosting his annual Summer Solstice party at his Northern Cross Observatory site. Contact Doug Bock for more information and/or directions to these events.

Bob MacFarland reported on the activities of the public relations committee and the events that our club is involved with. These include the SMAAC meeting at Eastern Michigan University (already concluded by the time you read this). The Lake Erie Comet Party on April 4th and 5th. The Astronomy Day Celebration on April 6th, we are still in negotiations with Oakland Mall regarding this celebration and more information on this event will be available at our next general membership meeting. Plans are well underway for the big comet party at Kensington Metro Park on April 25-26th to be held in association with other South Eastern Michigan Astronomy Clubs (SMAAC, again, with thanks too EMU for the use of the acronym). If you are planning on attending the Kensington party, please let us know if you are going to set up a telescope and if you will require AC. power for operation. We would like to have this information by March 20th so that we can notify the park authorities.

Over our usual pizza and pop, members were given the opportunity to introduce themselves and give a brief description of their viewing experiences since our last meeting. It was apparent that, due to cloudy weather, many telescopes remained packed away this past month. Most of the discussion centered around naked eye and binocular views of Hale-Bopp in the pre-dawn sky.

Mr. Bob Justin of the EMU Astronomy Club gave a talk on the cleaning and collimation of a Schimdt-Cassegrain telescope. He demonstrated the removal of the corrector lens on the Schimdt and discussed the proper cleaning methods. Bob suggested that the best collimation could be done in the field using the de-focused bright star method using a hi-powered ocular. We would like to thank Bob for his very informative presentation. ☆

MARCH SPACE HISTORY

The following March events come from the 01/25/97 edition of "Space Calendar." This calendar is compiled and maintained by Ron Baalke (baalke@kelvin.jpl.nasa.gov).

Mar 01 15th Anniversary (1982), Venera 13 Venus Flyby/Landing (USSR)
Mar 03 25th Anniversary (1972), Pioneer 10 Launch (Jupiter/Saturn Flyby)
Mar 05 15th Anniversary (1982), Venera 14 Venus Flyby/Landing (USSR)
Mar 10 20th Anniversary (1977), Discovery of Rings Around Uranus
Mar 16 35th Anniversary (1962), Maiden Launch of the Titan 2 Rocket
Mar 16 35th Anniversary (1962), 1st Cosmos Launch (USSR)
Mar 22 15th Anniversary (1982), STS-3 Launch (Columbia)
Mar 27 25th Anniversary (1972), Venera 8 Launch (Venus Lander) ☆

MARCH 1997 SPACE EVENTS

The following March 1997 events come from the 01/25/97 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.

Mar 03 SWAS Pegasus XL Launch
Mar 05 Tempo-2 Atlas-2A Launch
Mar 14 Minisat-01 Pegasus XL Launch
Mar 15 Mars Pathfinder Passes Mars Global Surveyor En Route to Mars
Mar 15 Forte Pegasus XL Launch ☆

ASTRONOMY WORKSHOP

The following article was reprinted from Astronet, Issue 56, February 1, 1997.

GARY'S GUIDE TO THE WELL BAFFLED NEWTONIAN
From: gseronik@direct.ca

One of the biggest knocks against Newtonian reflectors, compared with the finest of refractors, is inferior contrast. There are many reasons for this, but perhaps the most significant is that commercially made reflectors, and a fair share of home-built ones too, are not properly baffled. For some reason, baffling a Newtonian is viewed as either being impossible or of little value. Neither is the case! In truth, one of the easiest and least expensive ways of improving your reflector's image contrast is through proper baffling.

Step One: The Tube

Most commercial and home built telescopes have as their principle baffle a flat black tube interior. Usually this is accomplished with a coat or two of flat black paint. This is OK, but for optimum performance you can do a lot better.

The first thing to do is find a paint that is really flat black, and not just a dull grey. It's surprising the degree of difference that exists between paints. Some are not very flat, almost a gloss, and some are just not very black! Experiment if you can. I find that Krylon's Ultra-flat Black is nice and dark, but the fumes are nearly fatal. For my money, the best paint is Benjamin Moore's Alkyd Sani-Flat (black 204-80) interior flat paint. Flat black paint alone is good, but applied over a rough surface it is even better. Here's what I do:

1. Give the inside of the tube a good coat of the flattest black paint you can find.

2. While the paint is still wet, pour Slip-Not (a grainy material - crushed up walnut shells I think - designed to make slippery surfaces, such as stairs, less so) or sawdust down the tube and roll it around while it is lying on its side. The idea here is to give the inside of your tube a good coating of this stuff.

3. After the above has dried thoroughly, bang on the tube side to knock loose any clumps of material that are just waiting to fall. Don't go nuts here, you just want to get rid of the really loose stuff.

4. Apply another coat of the flat black using a sponge or a brush but with a dabbing motion and let dry.

5. Apply a second coat the same way as in 4.

It goes without saying (I hope) that the above is done with your optics and hardware removed!

By the time this dries, your Slip-Not or sawdust should be effectively sealed under two coats of paint and no amount of banging on your tube should loosen anything! The inside of your tube will now be very black. In fact, if you've missed any spots, they will appear immediately obvious by their glare, and you'll wonder how you saw anything in your scope when the whole tube was like that!

Step Two: The Hardware

OK, that takes care of the tube. But before you reinstall your optics have a look at your secondary mirror. Is the unused part of diagonal that faces the focuser exposed? If it is, paint it black. I use a small model brush for this and go slowly and carefully. The only part that you want shining into the focuser is the part that does something. Some diagonal holders take care of this problem, some do not. How about your spider - any shiny metal exposed? If so, either paint it or cover it in some other way. Take care though not to get paint on any screws that are necessary for adjustment - there's no sense in destroying your ability to collimate for the sake of improved contrast.

Next, check your primary mirror and mirror cell. Any shinola there? How about your mirror's bevel? This is worth taking care of if you're up to it. However, if going anywhere near the front of your primary mirror with a paint brush loaded with flat black paint makes you nervous, skip it. There is no point in becoming a nervous wreck over optimising your scope. Actually, this operation doesn't have to be nerve wracking. If you put your mirror on a Lazy-Susan (politically incorrect or what!) or a record turntable and brace your painting hand in some way, you can keep the brush stationary while you rotate the mirror under it. I prefer to use a chisel tip felt marker for this operation as it is easier to control.

OK, now have a look at your focuser and its hardware. Any shiny parts that project into the tube should be taken care of if possible. Again paint where you can, cover some other way where you can't.

Step Three: Finishing Up

Now put your scope back together and, without using an eyepiece, look into your focuser. All you should see is your primary reflected in your secondary and nothing else! Can you see past your primary and out the back of your tube? This is an often overlooked but serious source of stray light. Some kind of light tight cover around the inside circumference of the tube is in order here. It should not be necessary to completely cover the back of the tube, just the area that you can see around the primary.

You're almost done now, just one more place to check. Rack your focuser in all the way and put your eye up to it again. Move your eye around and look up the tube. Can you see over the top of the front of the tube? If you can, you've found another source of stray light. Light can shine past the top of your tube and fall directly on your eyepiece's field lens. This creates a tremendous contrast-killing glow, but the cure is simple enough: a dew cap! In most Newtonians, extending the tube actually does as much to improve contrast as it does to reduce the formation of dew on the secondary mirror.

Some telescope makers go even further, inserting a series of annular "ring" baffles down the length of the tube - rather like those found in refractors. It is a source of much debate, whether or not these help. However, if you are using a fan to smooth the air flow in your telescope then these additional baffles should be avoided as their presence will force the moving air into the light path. Secondly, if you do everything mentioned above, the improvement possible with these ring baffles (assuming for the time being they actually do have an effect) is unlikely to be of such a magnitude that you would even notice it in practise.

By improving your telescope's baffling, and keeping the optics clean, your telescope should offer the maximum contrast possible and be that much closer to perfection. Every little improvement helps after all. ☆

CALTECH QUESTION OF THE WEEK

Question: How often do meteors and meteorites fall to Earth? Submitted by Bob and Pat Gaskill, Orange County. Answered by Dr. William Bottke, Texaco Prize Fellow, Division of Geological and Planetary Sciences, Caltech

Meteors and meteorites are small rocky fragments of other planetary bodies that fall to Earth. When they do so, they often produce spectacular audible and visual effects that can be seen from the ground. Meteorites, objects that survive their fiery passage through Earth's atmosphere, are of particular interest to scientists, since they are pieces of planetary bodies (mostly asteroids) for which samples have not yet been obtained through either manned or unmanned space missions. The oldest meteorites are remnants of the very first processes to occur in our solar system 4.6 billion years ago, giving us a glimpse into what conditions were when Earth was formed.

One common class of meteor is called a "fireball," named for the bright, streaming orbs produced when the surface of a fist-sized or larger body is boiled away by friction as it enters Earth's atmosphere. Fireballs decelerate from speeds of about 60,000 m.p.h. to 200 m.p.h. during this passage, often slowing enough at the end so that they literally drop to the ground. Their flight path is similar to a golf ball thrown at an angle into a swimming pool; once the water stops the forward momentum of the ball, it sinks to the bottom of the pool. The meteor is often not strong enough to survive this passage intact, which can make recovery of the fragments difficult. Fireballs are mostly seen crossing the sky at night, though some are so bright they can be seen during the day. When a fireball is seen, it is usually several miles high. If any surviving meteoritic pieces were to survive to reach the ground, they would probably be over 500 miles from the observer. If enough people see the fireball from separate locations, however, scientists may be able to calculate where the fragments should strike Earth.

Studies indicate that about 25 meteorites weighing more than a fifth of a pound fall on California (or an area of equal size) each year. Three or four of these samples weigh about two pounds and are the size of your fist. Using these values, we can estimate that between 300 and 400 of these larger meteorites have fallen on California since the turn of the century. Most of these rocks, though, have not been found, leaving open the possibility that you yourself may discover one someday. ☆

BINOCULAR ADVICE

From: George Zay (GeoZay@aol.com) via Astronet, Issue 52, Dec. 15, 1996.

The following article was written by Malcolm J. Currie (England) and published in IMO's Dec. 1994 edition of the WGN Journal. Some time ago, I typed it out to send out to various people within North American Meteor Network.

WHAT IS THE BEST EQUIPMENT FOR SEEING TELESCOPIC METEORS?

There is no single best-buy telescope or binocular. There is a wide selection of suitable instruments; the choice will depend on the quality of your observing site, your eyesight, observing goals, and how much you wish to pay or what is already available. However, there are two main factors that should influence your choice: the instrument should have a low power and a wide apparent field of view. They both affect the number of meteors seen in a given time.

THE MAGNIFICATION PER UNIT APERTURE

You must have a low magnification for a given size of objective lens or mirror. To put that into numbers, the magnification should be in the range of 1.4 - 2.0 times the aperture in centimeters. So, for example, a 7x50 binocular has a magnification 1.4x the aperture in cm, and a 10x50 has magnification twice the aperture. To explain how these numbers arise here is a brief optics lesson. If you hold a telescope or binocular to the light and away from your eye, you will see a small illuminated disk, called the exit pupil. Its diameter is given by the telescope aperture divided by the magnification. As this is just the inverse of our factor, a given factor produces a certain sized exit pupil regardless of the telescope's aperture. So returning to our specific limits, a factor of 1.4x has a 7mm exit pupil and 2.0x has a 5mm beam. For normal mortals, a 7mm beam is as much as the pupil of the dark-adapted eye can handle, and may be too wide for older observers. Also, if your site has some light pollution, a slightly higher magnification will let you see more meteors as the contrast is improved.

Through the telescope, most meteors appear as lines rather than points, but nevertheless, like for stars, you can still see fainter with additional magnification. You can only take this so far. As magnification is increased, the true field of view is decreased, and the area of atmosphere being viewed reduces as the inverse square of the magnification, and so the observed rate falls. That is not all. Due to the increased magnification the apparent speed of the meteors is accelerated, which reduces the apparent brightness of meteors, and so more meteors will pass through the field undetected. There comes a point where the improved visibility of faint meteors is offset by the loss of area being viewed. This is approximately 2x the aperture in cm. Binoculars with 6mm exit pupils are unfortunately much rarer than the standard 7mm ones, though it is getting better. For example, Celestron produce a 7x42 and an 8x50. If sky conditions are too bright, you can always stop down the objective lens for better contrast.

THE APPARENT FIELD OF VIEW

The apparent field of view is governed by the eyepiece design. You can derive it from the product of the magnification and the true field of view. For example, a 10x50 binocular, with a 6 degree true field, has an apparent field of 60 degrees. A wide field of view will encompass more of the sky, and hence you will see more meteors. The recommended range is 45-70 degrees, with 50-60 degrees being preferred. You may be wondering why we set an upper limit. One of the principal reasons for observing telescopic meteors is to investigate radiant properties by plotting meteor paths accurately. As the apparent field enlarges, the average plotting accuracy goes down. So ultra-wide fields (>65 deg) are best for determining rates, and hence deriving the time of maximum for a shower; whereas for field sizes around 50 degrees rates are still reasonable (because the eye perceives only a fraction of the meteors in the outer 10 deg annulus) and accurate positional data can be obtained. Given the choice between the two, you should err on the side of the smaller apparent field as it offers more flexibility and science. Also, ultra-wide eyepieces or binoculars are either very expensive if they give pinpoint images across the entire field, or give increasingly distorted images towards the periphery of the field. Below 50 deg the loss of sky coverage starts to be come important. If rates become too low boredom and loss of concentration can soon set in.

BINOCULAR versus TELESCOPE

Binocular vision is the natural way to look, and since comfort is a critical consideration for the telescopic observer, a binocular is preferred to a (monocular) telescope. There has been debate in the literature by how much it improves the limiting magnitude from nothing to about a magnitude. A telescope with a star diagonal is more flexible for viewing fields close to the zenith, and if you want a larger aperture, will be far less expensive. Angled binoculars only seem to come with large apertures and even larger price tags.

APERTURE

Aperture is less critical, and IMO observers' apertures range from 40mm to 300mm, though most are in the range 50-80mm. Certain showers like the Perseids are progressively weaker towards fainter magnitudes and this suggests a small aperture is best, say a 6x30. Increasing the aperture increases the average meteor magnitude and so exaggerates any mass-sorting within the stream, and will give improved plotting accuracy. The intermediate apertures (50-80mm) look best.

OPTICAL QUALITY

The quality of the optics can make a big difference to the performance. Remember that you will be observing for long periods and considerations like accurate collimation and pinpoint images will reduce strain. This consideration can outweigh some of those mentioned already. For example, a quality 7x42 is going to let you see more meteors than a cheap 8x50.

In conclusion, an 8x50 or 10x60 binocular with a 55 degree apparent field would be excellent for telescopic meteors. Many other similar combinations will perform well too. ☆

ASTRONOMY BOOK REVIEWS

from dec 96 SpaceViews http://www.seds.org/spaceviews/9612/

The Planet Mars: A History of Observations and Discovery
by William Sheehan, University of Arizona Press, 1996

No other planet in the solar system has created such interest and fascination in as Mars. Since earliest times, when it appeared as a red star wandering through the skies, symbolic of blood and war, to the present and near-future spacecraft missions to the planet, humanity has given Mars a special place it its collective mind. William Sheehan explores the history of our study of the Red Planet in The Planet Mars.

While the first chapter of the book explores the "prehistory" of human study of Mars, up to Kepler's study of its orbit, the book's detailed history gets going in chapter 2 with the first telescopic observations of Mars in the 17th century. Sheehan writes a detailed (he includes over 25 pages of notes at the end of the text) but very readable history of observations from Mars. Special attention is given to the "discovery" of canals on the planet, of course, but they do not receive undo attention.

Spacecraft studies of Mars are included as well, but they do not get the same attention here as in other books. The spacecraft history provided here is almost entirely American; Soviet efforts receive scant attention, a disappointment considering the scope of the rest of the text. Otherwise, however, The Planet Mars is a good history of our study of the planet. Sheehan's text provides a good description of how we have looked at Mars in the past, and can help the reader put some of the news of the present and plans for the future in perspective.

Orbit: NASA Astronauts Photograph the Earth
by Jay Apt, Michael Helfert, and Justin Wilkinson
National Geographic Society, 1996

pictures of planets, moons, stars and distant galaxies and other cosmic phenomena. Yet, some of the best, and most well received, photos have been pictures of our own Earth taken from space. Whether its the ability to look at the planet without the usual reference marks of labels and borders, or the new perspective space provides on familiar features, images of the Earth have been among the most popular space images taken to date. A shuttle astronaut and two earth scientists have compiled nearly 200 of the best pictures into the beautiful book Orbit.

The book is laid out like the flight plan of the shuttle. The first section is Africa, the first landmass encountered by shuttle astronauts after launch. Later chapters follow the progression of the shuttle in orbit: Europe and the Middle East, Asia, the Pacific, Middle and South America, and North America. A special section in the middle of the book provides some astounding views of the Earth's aurora as seen by the shuttle. The text of the book is kept to a minimum: some introductory comments in each chapter, explanatory captions for each picture, and some additional information at the beginning and end of the book.

It is difficult to describe the quality of the pictures here. They are beautiful, amazing, educational, and more. Each picture is in rich color and many fill one or two of the books oversized (10.75" by 12") pages. At a price of $40, Orbit may seem like a bit much for what could be described as simply a fancy picture book, but it's really quite a bargain for the sheer beauty of the book. ☆

REVISED SCALE OF COSMOS

European Space Agency (ESA), Press Information Note No. A1 04-97

ESA's Hipparcos satellite revises the scale of the cosmos

The observable Universe may be about 10 percent larger than astronomers have supposed, according to early results from the ESA's Hipparcos mission. Investigators claim that the measuring ruler used since 1912 to gauge distances in the cosmos was wrongly marked. This ruler relies on the brightnesses of winking stars called Cepheids, but the distances of the nearest examples, which calibrate the ruler, could only be estimated. Direct measurements by Hipparcos imply that Cepheids are more luminous and more distant than previously imagined. The brightnesses of Cepheids in other galaxies are used as a guide to their distances. All of these galaxies may now be judged to lie farther away. At the same time the Hipparcos Cepheid scale drastically reduces the ages of the oldest stars, to about 11 billion years. By a tentative interpretation the Universe is perhaps 12 billion years old.

Michael Feast from the University of Cape Town, South Africa, announces his conclusion about the Cepheids at a meeting devoted to Hipparcos at the Royal Astronomical Society in London. It will provoke much comment and controversy, because the scale and age of the Universe is the touchiest issue in cosmology. The best hope for confirming or modifying the result now rests with studies using Hipparcos data on other kinds of variable stars. An investigation of variables called Miras, by Floor van Leeuwen of Royal Greenwich Observatory, Cambridge, and his colleagues, is described at the same London meeting.

European teams of scientists and engineers conceived and launched the unique Hipparcos satellite, which operated from 1989 to 1993. Hipparcos fixed precise positions in the sky of 120,000 stars (Hipparcos Catalogue) and logged a million more with a little less accuracy (Tycho Catalogue). Since 1993 the largest computations in the history of astronomy have reconciled the observations, to achieve a hundredfold improvement in the accuracy of star positions compared with previous surveys. Slight seasonal shifts in stellar positions as the Earth orbits the Sun, called parallaxes, give the first direct measurements of the distances of large numbers of stars. With the overall calculations completed, the harvest of scientific discoveries has begun. Among those delighted with the immediate irruption into cosmology, from this spacecraft made in Europe, is ESA's director of science, Roger Bonnet. "When supporters of the Hipparcos project argued their case," Bonnet recalls, "they were competing with astrophysical missions with more obvious glamour. But they promised remarkable consequences for all branches of astronomy. And already we see that even the teams using the Hubble Space Telescope will benefit from a verdict from Hipparcos on the distance scale that underpins all their reckonings of the expansion of the Universe."

The pulse-rates of the stars

Cepheid stars alternately squeeze themselves and relax, like a beating heart. They wax and wane rhythmically in brightness, every few days or weeks, at a rate that depends on their luminosity. Henrietta Leavitt at the Harvard College Observatory discovered in the early years of this century that bigger and more brilliant Cepheids vary with a longer period, according to a strict rule. It allows astronomers to gauge relative distances simply by taking the pulse-rates of the Cepheids and measuring their apparent brightnesses. Nearby Cepheids are typically 1000-2000 light-years away. They are too far for even Hipparcos to obtain very exact distance measurements, but by taking twenty-six examples and comparing them, Michael Feast and his colleague Robin Catchpole of RGO Cambridge arrive at consistent statistics. These define the relationship between the period and the luminosity, needed to judge the distances of Cepheids. The zero point is for an imaginary Cepheid pulsating once a day. This would be a star 300 times more luminous than the Sun, according to the Hipparcos data. The slowest Cepheid in the sample, l Carinae, has a period of 36 days and is equivalent to 18,000 suns.

Applied to existing data on Cepheids seen in nearby galaxies, the Hipparcos result increases their distances. It pushes the Large Magellanic Cloud away, from 163,000 light-years, the previously accepted value, to 179,000 light-years with the Hipparcos Cepheid corrections, an increase of 10 percent. Feast and Catchpole feed this result back to our own Milky Way Galaxy, and into calculations of the age of globular clusters, which harbour some of the oldest stars of the Universe. The reckoning involves another kind of variable star, the RR Lyraes, and the Hipparcos investigators arrive at an age of 11 billion years for the oldest stars. Other estimates of the oldest stars assigned to them an age of 14.6 billion years. This seemed, absurdly, to leave them older than the Universe. A team of astronomers using the Hubble Space Telescope recently declared the Universe to be only 9-12 billion years old. The Hipparcos Cepheid result increases that Hubble-inferred cosmic lifespan to 10-13 billion years. "I hope we've cured a nonsensical contradiction that was a headache for cosmologists," Michael Feast says. "We judge the Universe to be a little bigger and therefore a little older, by about a billion years. The oldest stars seem to be much younger than supposed, by about 4 billion years. If we can settle on an age of the Universe at, say, 12 billion years then everything will fit nicely."

Feast and Catchpole have also cleared up a mystery about the nearest and most familiar Cepheid variable. This is Polaris, the Pole Star. Imperceptibly to the human eye, its brightness varies at a relatively high rate, every 3 days. That should make it, by the Cepheid rule, a feebler star than it appears to be. Hipparcos fixes the distance of Polaris at 430 light-years, and the researchers conclude that Polaris pulsates with an overtone, at a rate 40 per cent faster than expected for a Cepheid of its size and luminosity. Several other Cepheids gauged by Hipparcos also exhibit overtones. Were these not recognized as fast pulsators they would give false impressions in the Cepheid distance scale.

The miraculous stars

Another famous variable star pulsates at more than twice the frequency that theorists would expect. This is Mira, the prototype of the class of stars investigated by Floor van Leeuwen and his colleagues, using the Hipparcos data. To an unaided eye, Omicron Ceti appears and disappears in a cycle of 11 months. In the 17th Century astronomers named it Mira, the miraculous star. Astrophysicists today interpret Mira as a senile star slightly more massive than the Sun. It has swollen into a red giant and started oscillating, as a prelude to greater instabilities that will in due course fling the outer layers of the star into space. Hipparcos fixes Mira's distance at 420 light-years. Other astronomers have gauged the apparent width of the star, as seen from the ground, so the Hipparcos team can compute the diameter of Mira as 650 million kilometres — somewhat wider than the orbit of Mars. If the Sun were in Mira's state it would swallow up the Earth and all of the inner planets.

Astronomers knew that Mira was big, but the Hipparcos result confirms that it is too large to be oscillating in a simple fashion. Again its variation is an overtone, and the same is true of some other variable stars of the same type, known collectively as the Miras. The sixteen Miras in the survey are mostly 300-1000 light-years away, at distances more comfortably within the grasp of Hipparcos parallaxes. Before Hipparcos, there was only one fairly good measurement of a Mira distance, for the star R Leonis. Even in that case, Hipparcos adjusts the distance from 390 to 330 light-years. Patricia Whitelock of the South African Observatory played a prominent part in the Mira study. In preparation for the Hipparcos data, observations of selected Miras from South Africa and Russia, with infrared instruments, assessed the extent to which they are dimmed by dust. Taking this effect into account, as well as the occurrence of overtones, the team arrives at a cosmic distance scale. As with the Cepheids, they can deduce distances by comparing the brightness of a Mira with its period of variation.

Applied to the Large Magellanic Cloud, where Miras have been detected, the Hipparcos Mira scale puts the galaxy at 166,000 or 171,000 light-years, depending on the method of calculation preferred. This result is intermediate between the commonly accepted distance to the Large Magellanic Cloud and the new result from the Hipparcos Cepheid scale. "Frankly the Cepheids are at the limit of the useful range of Hipparcos, for distance measurements," comments Floor van Leeuwen. "And as for the Miras, ours is the very first attempt to gauge the absolute distance to another galaxy via parallax measurements on this type of star. So I think we should be grateful to Hipparcos, that our earliest answers are in the right ballpark and in fairly good agreement, without being hasty in drawing cosmological conclusions."

Only the beginning

Michael Perryman, ESA's project scientist for Hipparcos, anticipates a warm debate among astronomers. Should the Hipparcos Cepheid results be taken at face value, with all their implications for the size and age of the Universe? He remains confident that the issue will be settled by other results quarried from the data. Further Hipparcos studies of variable stars, including the RR Lyraes, are in progress. Also relevant to the distance scale are differing quantities of heavy elements present in stars of different ages, which can affect their luminosities. Any remaining confusion on this point will be dispelled by mainstream Hipparcos research devoted to the basic astrophysics of stars of different ages of origin, and at different stages of their life cycles. "Until Hipparcos, the cosmic distance scale rested on well-informed guesses," Michael Perryman says. "The distances we now have, for stars of many kinds, provide for the very first time a firm foundation from which to gauge the distances of galaxies. The work has only just begun. If it should turn out that the Cepheids have given the final answer straight away, that might be surprising."

STATISTICALLY SPEAKING

Location (Dearborn, MI): 42°19'12" N, 83°10'48" W, 180 meters elevation
Local Time = Universal Time - 5 hours (Eastern Daylight 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 March 1997

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
2 SR: 7:06 SS: 18:24 MR: 1:35 MS: 11:44	3 SR: 7:05 SS: 18:25 MR: 2:34 MS: 12:36	4 SR: 7:03 SS: 18:26 MR: 3:30 MS: 13:36	5 SR: 7:01 SS: 18:28 MR: 4:23 MS: 14:42	6 SR: 7:00 SS: 18:29 MR: 5:11 MS: 15:53	7 SR: 6:58 SS: 18:30 MR: 5:55 MS: 17:07	8 SR: 6:56 SS: 18:31 MR: 6:35 MS: 18:22
9 SR: 6:55 SS: 18:32 MR: 7:13 MS: 19:37	10 SR: 6:53 SS: 18:34 MR: 7:50 MS: 20:49	11 SR: 6:51 SS: 18:35 MR: 8:27 MS: 22:00	12 SR: 6:50 SS: 18:36 MR: 9:06 MS: 23:07	13 SR: 6:48 SS: 18:37 MR: 9:46 MS: None	14 SR: 6:46 SS: 18:38 MR: 10:29 MS: 0:11	15 SR: 6:44 SS: 18:39 MR: 11:16 MS: 1:09
16 SR: 6:43 SS: 18:41 MR: 12:05 MS: 2:02	17 SR: 6:41 SS: 18:42 MR: 12:57 MS: 2:50	18 SR: 6:39 SS: 18:43 MR: 13:50 MS: 3:32	19 SR: 6:38 SS: 18:44 MR: 14:45 MS: 4:10	20 SR: 6:36 SS: 18:45 MR: 15:41 MS: 4:45	21 SR: 6:34 SS: 18:46 MR: 16:38 MS: 5:17	22 SR: 6:32 SS: 18:47 MR: 17:35 MS: 5:46
23 SR: 6:31 SS: 18:49 MR: 18:32 MS: 6:15	24 SR: 6:29 SS: 18:50 MR: 19:30 MS: 6:44	25 SR: 6:27 SS: 18:51 MR: 20:29 MS: 7:14	26 SR: 6:25 SS: 18:52 MR: 21:29 MS: 7:45	27 SR: 6:24 SS: 18:53 MR: 22:29 MS: 8:19	28 SR: 6:22 SS: 18:54 MR: 23:29 MS: 8:58	29 SR: 6:20 SS: 18:55 MR: None MS: 9:41
30 SR: 6:18 SS: 18:56 MR: 0:28 MS: 10:30	31 SR: 6:17 SS: 18:58 MR: 1:23 MS: 11:26			March Lunar Events	Mar 2 Mar 8 Mar 15 Mar 23 Mar 31	LQ: 4:38 NM: 20:16 FQ: 19:07 FM: 23:46 LQ: 14:38

Lunar Eclipse Report for March 1997

Lunar eclipse on 3/23/1997
Moon rise: 18:32
Moon set: 6:15
Magnitude: 0.91
Partial phase begins: 22:00
Time of maximum eclipse: 23:40
Partial phase ends: 1:21

Planet View Info Report for March 1997

Date	Rise	Set	RA	Dec	Elongation	Ill Fr	DIST(AU)
Mercury							
3/ 5/1997	7:00	17:56	22h44m03s	-10°13'49"	6°11'05"	0.982	1.37541
3/12/1997	7:00	18:38	23h32m19s	-4°40'42"	1°35'15"	0.999	1.35631
3/19/1997	6:59	19:24	0h21m41s	1°40'30"	7°14'06"	0.962	1.28964
3/26/1997	6:55	20:08	1h09m54s	8°09'53"	13°51'53"	0.815	1.16254
Venus							
3/ 5/1997	6:53	17:48	22h38m03s	-10°06'20"	7°17'35"	0.992	1.70093
3/12/1997	6:46	18:05	23h10m47s	-6°49'45"	5°36'57"	0.996	1.71011
3/19/1997	6:38	18:22	23h42m59s	-3°24'14"	3°57'09"	0.998	1.71716
3/26/1997	6:30	18:40	0h14m53s	0°05'58"	2°22'04"	0.999	1.72205
Mars							
3/ 5/1997	19:33	8:04	12h10m56s	2°57'44"	162°43'31"	0.992	0.68645
3/12/1997	18:53	7:31	12h01m45s	3°55'08"	171°43'28"	0.998	0.66773
3/19/1997	18:11	6:57	11h51m36s	4°53'50"	175°40'15"	0.999	0.65971
3/26/1997	17:30	6:22	11h41m25s	5°47'56"	167°33'38"	0.996	0.66241
Jupiter							
3/ 5/1997	5:36	15:22	20h49m09s	-18°14'11"	34°44'03"	0.997	5.89323
3/12/1997	5:13	15:02	20h55m09s	-17°51'03"	40°15'35"	0.996	5.82482
3/19/1997	4:49	14:42	21h00m53s	-17°28'18"	45°48'51"	0.995	5.74837
3/26/1997	4:26	14:21	21h06m21s	-17°06'07"	51°24'15"	0.994	5.66461
Saturn							
3/ 5/1997	8:02	20:12	0h28m04s	0°38'27"	22°20'47"	1.000	10.37841
3/12/1997	7:37	19:48	0h31m10s	0°58'47"	16°13'52"	1.000	10.41640
3/19/1997	7:11	19:25	0h34m20s	1°19'20"	10°12'33"	1.000	10.44239
3/26/1997	6:45	19:02	0h37m32s	1°39'58"	4°28'22"	1.000	10.45625
Uranus							
3/ 5/1997	5:28	15:06	20h37m29s	-19°07'26"	37°38'11"	1.000	20.58301
3/12/1997	5:01	14:40	20h38m51s	-19°02'31"	44°18'17"	1.000	20.50670
3/19/1997	4:35	14:14	20h40m06s	-18°58'00"	50°58'16"	1.000	20.42048
3/26/1997	4:08	13:48	20h41m15s	-18°53'55"	57°38'12"	1.000	20.32562
Neptune							
3/ 5/1997	4:58	14:29	20h04m31s	-19°55'45"	45°22'44"	1.000	30.84229
3/12/1997	4:31	14:03	20h05m19s	-19°53'22"	52°11'18"	1.000	30.75264
3/19/1997	4:04	13:36	20h06m02s	-19°51'13"	58°59'25"	1.000	30.65429
3/26/1997	3:37	13:09	20h06m39s	-19°49'20"	65°47'04"	1.000	30.54869
Pluto							
3/ 5/1997	0:33	11:34	16h23m45s	-8°43'14"	98°38'34"	1.000	29.79619
3/12/1997	0:06	11:06	16h23m47s	-8°40'50"	105°27'47"	1.000	29.68254
3/19/1997	23:34	10:39	16h23m42s	-8°38'15"	112°16'07"	1.000	29.57286
3/26/1997	23:06	10:11	16h23m31s	-8°35'31"	119°02'56"	1.000	29.46876

Planet Conjunction/Opposition Report for March 1997

3/11/1997	Mercury	@ Superior Conjunction	Hour: 18
3/17/1997	Mars	@ Opposition	Hour: 03
3/30/1997	Saturn	@ Conjunction	Hour: 18

Planet Apsides Report for March 1997

3/26/1997 Mercury @ Perihelion Distance from Sun: 0.31 AU

Moon Apsides Report for March 1997

Date	Hour	Apsis	Distance (km)	Diameter
3/ 8/1997	4	Perigee	357751	0.5567°
3/20/1997	18	Apogee	405977	0.4906°

Twilight Report for March 1997

	Sun		Astronomical		Nautical		Civil	
Date	Rise	Set	Begin	End	Begin	End	Begin	End
3/ 5/1997	7:01	18:28	5:24	20:05	5:56	19:33	6:29	19:00
3/12/1997	6:50	18:36	5:12	20:14	5:45	19:41	6:17	19:08
3/19/1997	6:38	18:44	4:59	20:22	5:32	19:49	6:05	19:16
3/26/1997	6:25	18:52	4:46	20:32	5:20	19:58	5:53	19:25

SKY & TELESCOPE NEWS BULLETINS

from the editors of Sky & Telescope magazine

VIRGO'S EXTRAGALACTIC STARS

Central to our mental map of the cosmos is the notion that stars reside solely in galaxies. But evidence is now in hand that trillions of stars in the Virgo Cluster lie beyond the gravitational embrace of the group's individual galaxies. As Henry C. Ferguson (Space Telescope Science Institute) explained to the American Astronomical Society this January, he and his colleagues have actually resolved individual stars in a 2-arcminute-wide field 50 arcminutes east of M87, the giant elliptical galaxy at the cluster's core. After subtracting star counts from control frames, the group found an excess of about 600 stars, each nearly one billion times too faint to see with our eyes on Earth. If the interlopers are indeed at the Virgo Cluster's distance of about 65 million light-years, their colors and magnitudes would match those expected for old low-mass stars in their brightest red-giant phase. Furthermore, they would lie at least one million light-years from M87 — half the distance between our Milky Way and the Andromeda Galaxy.

HUBBLE SERVICING MISSION

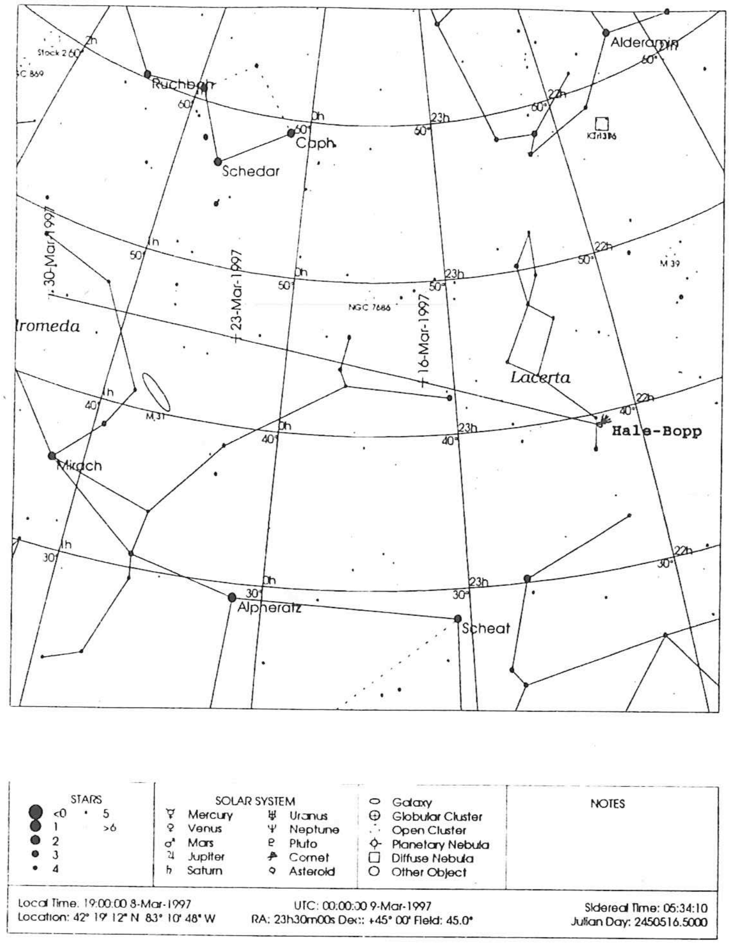
Early on February 14th, a pair of spacewalking astronauts aboard the Space Shuttle *Discovery* successfully installed two new instruments on the Hubble Space Telescope. The one dubbed NICMOS (Near-Infrared Camera and Multi-Object Spectrometer) will explore the universe at infrared wavelengths longer than 1 micron. The other package, called STIS (Space Telescope Imaging Spectrograph) will obtain the spectra of many objects simultaneously. Project scientists say the instruments have passed a "liveness" test, but that it will be several weeks before all their systems can be checked out. STIS, for example, operates with a high-voltage power supply that can't be turned on until air inside the instrument has been completely evacuated. Look for the first press conference to show off new results in early May. For a firsthand account of the mission, see astronomer-astronaut Steve Hawley's article in SKY & TELESCOPE's February issue, or check it out electronically at http://www.skypub.com/news/hstsm2.html.

HIPPARCOS RESULTS

In February European astronomers announced a series of results from the Hipparcos mission, though the full data set will not be made public until June. Launched in August 1989, the spacecraft spent several years measuring the positions of stars down through magnitude 11 with unprecedented accuracy. Among the new findings is that the Pleiades star cluster appears to be about 10% nearer than previously thought. Hipparcos data pegs the distance at 360 light-years. Also Cepheid variables, the pulsating stars that astronomers use to gauge the distances to other galaxies, are intrinsically more luminous — and thus farther away — than believed. This implies that the universe may be larger than previous estimates by about 10%, and also that the most distant (and thus oldest) stars are no more than about 11 billion years old. Cosmologists should find that good news, since they now estimate that the universe as a whole is some 12 billion years old.

SN 1987A's ANNIVERSARY

About 166,000 years ago, a star in the Large Magellanic Cloud became a supernova, violently spewing its outer layers into space and sending an incredible burst of light in all directions. That flash of light reached Earth 10 years ago this week, on the night of February 23-24, 1987, and briefly reached magnitude 2.9. In the years since this supernova, designated SN 1987A, has been a boon to astrophysicists who study the lives and deaths of stars. They now suspect that the exploding star had once been a blue star with about 20 times the Sun's mass. In time it swelled into a red giant, lost a lot of mass through a stellar wind, then contracted and heated up as a blue supergiant. Eventually its core collapsed, triggering the explosion. For the complete story on SN 1987A, see supernova expert Robert Kirshner's article in the February issue of SKY & TELESCOPE.



COMET HALE-BOPP EPHEMERIS

JPL Ref. Orbit 48 by D.K. Yeomans, Jan. 27, 1997

Date(UT)	R.A. J2000	Dec.	Delta	r	Theta	Beta	Moon	PsAng	PsAMV	TMag
Mar 1	21 21 59	+33 17 13	1.489	1.067	45.7	41.7	96	329.5	231.3	.7
Mar 2	21 27 35	+34 02 50	1.474	1.059	45.9	42.2	88	330.3	232.7	.6
Mar 3	21 33 25	+34 48 25	1.460	1.050	46.0	42.7	80	331.1	234.1	.6
Mar 4	21 39 27	+35 33 52	1.447	1.042	46.0	43.3	72	331.9	235.6	.5
Mar 5	21 45 44	+36 19 02	1.434	1.033	46.1	43.8	64	332.9	237.1	.5
Mar 6	21 52 14	+37 03 48	1.421	1.025	46.2	44.3	57	333.9	238.7	.4
Mar 7	21 58 59	+37 47 58	1.409	1.018	46.2	44.7	51	335.0	240.3	.4
Mar 8	22 05 58	+38 31 25	1.398	1.010	46.2	45.2	47	336.2	241.9	.4
Mar 9	22 13 13	+39 13 57	1.387	1.003	46.2	45.7	45	337.5	243.7	.3
Mar 10	22 20 43	+39 55 23	1.377	.996	46.2	46.1	46	338.8	245.4	.3
Mar 11	22 28 29	+40 35 31	1.368	.989	46.2	46.5	50	340.2	247.2	.2
Mar 12	22 36 30	+41 14 09	1.360	.982	46.2	46.9	55	341.8	249.1	2
Mar 13	22 44 46	+41 51 04	1.352	.976	46.1	47.2	62	343.4	251.0	.2
Mar 14	22 53 17	+42 26 04	1.344	.970	46.0	47.6	69	345.1	253.0	.1
Mar 15	23 02 04	+42 58 56	1.338	.964	46.0	47.9	76	346.8	255.1	.1
Mar 16	23 11 04	+43 29 27	1.332	.959	45.9	48.1	83	348.7	257.1	.1
Mar 17	23 20 17	+43 57 25	1.328	.953	45.7	48.4	90	350.6	259.3	.1
Mar 18	23 29 42	+44 22 39	1.323	.948	45.6	48.6	97	352.6	261.5	.0
Mar 19	23 39 19	+44 44 57	1.320	.944	45.5	48.8	104	354.7	263.7	.0
Mar 20	23 49 05	+45 04 11	1.318	.940	45.3	48.9	110	356.8	266.0	.0
Mar 21	23 58 59	+45 20 12	1.316	.936	45.2	49.0	117	359.0	268.3	.0
Mar 22	00 08 59	+45 32 53	1.315	.932	45.0	49.1	123	1.3	270.6	.0
Mar 23	00 19 03	+45 42 09	1.315	.929	44.8	49.1	129	3.6	273.0	.0
Mar 24	00 29 09	+45 47 57	1.316	.926	44.6	49.1	134	5.9	275.4	-.1
Mar 25	00 39 16	+45 50 16	1.318	.923	44.4	49.1	138	8.2	277.7	-.1
Mar 26	00 49 21	+45 49 06	1.320	.921	44.1	49.0	140	10.6	280.1	-.1
Mar 27	00 59 22	+45 44 29	1.323	.919	43.9	48.9	141	13.0	282.5	-.1
Mar 28	01 09 18	+45 36 31	1.327	.917	43.7	48.7	138	15.3	284.8	-.1
Mar 29	01 19 06	+45 25 16	1.332	.916	43.4	48.5	134	17.7	287.1	-.1
Mar 30	01 28 45	+45 10 52	1.338	.915	43.1	48.3	128	20.0	289.4	-.1
Mar 31	01 38 13	+44 53 28	1.344	.914	42.9	48.0	120	22.3	291.7	.0
Apr 1	01 47 29	+44 33 15	1.351	.914	42.6	47.7	111	24.6	293.9	.0

R.A.Dec. = Geocentric astrometric right ascension and declination referred to the mean equator and equinox of J2000.
Delta = Geocentric distance of object in AU.
r = Heliocentric distance of object in AU.
Theta = Sun-Earth-Object angle in degrees.
Beta = Sun-Object-Earth angle in degrees.
Moon = Moon-Earth-Object angle in degrees.
PsAng = Position angle of extended radius vector in degrees.
PsAMV = Position angle of minus velocity vector in degrees.
TMag = Total magnitude.

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