# Star Dust

National Capital Astronomers, Inc. Washington, DC (301) 320-3621

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# NCA Member Harold Williams to Review Applications of Astrolabes

***By Wayne H. Warren Jr.***
***( including description by Harold Williams)***

The next meeting of the National Capital Astronomers will be held on November 6, 1993 at 7:30 PM in the Bunim Room of the Clinical Center (Building 10, floor 9) at the National Institutes of Health. Our own Harold Williams has agreed to give a talk on "Astrolabes — Past, Present, Future?" in the absence of both John Graham and Wayne Warren, who will both be away at scientific meetings.

Dr. Williams writes: "The astrolabe was the most important astronomical calculating device before the invention of digital computers and the most important astronomical observational instrument before the invention of the telescope. The first work of science education written in a language that may be called English (middle English, actually) was Geoffrey Chaucer's 'Treatise on the Astrolabe'. Chaucer, who today is known principally for writing the 'Canterbury Tales', wrote the above treatise for his ten-year-old son, Lewis, in 1387. Following is some of what Chaucer had to say about the astrolabe.

> 'Little Lewis my son, I have perceived well by certain signs thy ability to learn sciences touching numbers and proportions, and I also consider thy earnest prayer specially to learn the Treatise on the Astrolabe. Then forasmuch as a philosopher saith, "he wrappeth him in his friend, who condescendeth to the rightful prayers of his friend," therefore I have given thee an astrolabe for our horizon, composed for the latitude of Oxford, upon which, by means of this little treatise, I purpose to teach thee a certain number of conclusions appertaining to the same instrument. I say certain conclusions, for three reasons. The first is this: understand that all the conclusions that have been found, or possibly might be found in so noble an instrument as an astrolabe, are not known perfectly to any mortal man in this region, as I suppose.'"

Dr. Williams notes that he will have at least several astrolabes with him, two that he designed and built, and a metal one (not constructed by him) like Chaucer's, but with modern star positions.

Astrolabes, such as the Danjon instruments in France, have been used even in modern times to measure accurate star positions. Thus, Harold's talk will

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## November Calendar

***The Public is Welcome!***

**Tuesdays, November 2, 9, 16, 23, and 30, 7:30 PM** - Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

**Wednesday, November 3** - See "Sky Watch" column by Blaine P. Friedlander Jr. in The Washington Post "Style" section for other events of astronomical interest.

**Fridays, November 5, 12, 19, and 26, at 7:30 PM** - Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

**Fridays, November 5, 12, 19, 8:30 PM** - Open nights with NCA's Celestron-14 telescope with Bob Bolster, 6007 Ridgeview Drive, south of Alexandria off Franconia Road between Telegraph Road and Rose Hill Drive. Call Bob for details 703/960-9126.

**Saturday, November 6, 9:30 AM** - Priscilla Strain (NASM), "Lunar Landscapes." At NASM, Albert Einstein Planetarium.

**Saturday, November 6, 1993, 5:30 PM** - Dinner with the speaker at the Thai Place Restaurant (4828 Cordell Ave., Bethesda) before the monthly meeting. Reservations are for 5:30 PM.

**Saturday, November 6, 7:30 PM** - Dr. Harold Williams, "Astrolabes - Past, Present, Future?" Meeting will be held in the Bunim Room at the National Institutes of Health. For directions refer to map and description on inside back page.

**Saturday, November 13, 8:30 PM** - "Exploring the Sky." on Glover Road, NW, at the open field nearest the Rock Creek Park Nature Center. Information: 202/ 426-6829 (the Rock Creek Park Nature Center) or 301/320-3621 (National Capital Astronomers). Because of increased attendance, more telescopes are needed!

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# THE USNO ASTROMETRIC INTERFEROMETER

***by Wayne H. Warren Jr.***

At the September 11, 1993 meeting, NCA members and guests were pleased to have Dr. Donald J. Hutter of the U.S. Naval Observatory (USNO) describe that institution's collaborative project with the Naval Research Laboratory (NRL) and Lowell Observatory to build an Astrometric Interferometer (AI) at Anderson Mesa near Flagstaff, Arizona. The AI is a successor to the Mark III interferometer, which commenced operation in 1986 at Mount Wilson Observatory in California and continued until the end of 1992, at which time it was closed down to transfer personnel to the new project.

The new instrument, whose official name is "The Navy Prototype Optical Interferometer at Lowell Observatory," has a staff of about 30 persons. There will actually be two closely related instruments, one an astrometric interferometer designed to measure accurate stellar positions, the other an optical interferometer (known affectionately as BOA for "Big Optical Array") that will image objects such as the surfaces of stars other than the Sun. Although these two instruments will perform different functions, they are both located at the same site and will operate in a closely related manner.

Dr. Hutter first reviewed the history of optical interferometry, which employs the basic Michelson interferometer that was developed in the late nineteenth century by the American physicist Albert A. Michelson, and subsequently used by Michelson and Pease on the Mount Wilson 100-inch Hooker telescope to measure stellar angular diameters. The basic design employs two steerable light collectors consisting of flat mirrors that are pointed at the observed object at an angle. Thus, an object's light arrives at one mirror before the other. This "delay" is used to produce interference fringes that can be accurately measured to yield an exact value for the optical path length difference. Combining that length with the known baseline between the light collectors, we then have a simple plane trigonometric problem to determine the angle of the observed object. To determine accurate star positions, which are two-dimensional quantities, pairs of collectors are positioned at varying orientations and the resulting measurements are combined. The same instrument can also be used to measure stellar angular diameters by analyzing fringe visibility contrast (intensity differences between the bright and dark fringes).

Although, as mentioned previously, the basic principles of interferometry have been known for a long time, it is only within the past 15 years or so that these instruments have really become practical and productive, and this is because


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of the development of modern solid-state detectors and computer-controlled systems.

The Mark III interferometer, developed and built by USNO, NRL, MIT, and SAO (Smithsonian Astrophysical Observatory) showed that very accurate measurements could be made over rather large angles on the sky, the typical accuracy being about 10 milliseconds of arc (the angle subtended by a dime at a distance of about 800 km), but the Mark III had a limiting magnitude of about 5.5. A comparison of positions measured with the Mark III against those determined for the FK5 (the currently most accurate astrometric catalog having typical accuracies of 0.050 to 0.100 seconds of arc) shows a possible improvement of approximately a factor of 3, while the new instrument is expected to yield positional accuracies of typically a few milliseconds of arc (0.002). Another application of these measurements is to determine orbits for close binary stars by making a number of measurements of such a system as the Earth rotates during a night and the orientation of the binary system changes with regard to the baseline direction. Over many nights of observations, the orbital motion of a binary can thus be determined, from which fundamental parameters such as stellar masses can be derived.

The optical interferometric measurements are particularly valuable because their range of observability extends to smaller separations (<0.002 to 0.050") than speckle interferometry, while the latter (0.030 to 0.2") overlaps with visual techniques on the far (or wider) end. By combining interferometric measurements of close systems with parameters determined by spectroscopic techniques, from which relative velocities are derived, a complete description of a system, including masses and angular orientation, can be calculated. The Mark III instrument was used to measure about 130 binary systems, from which 43 were suitable for continuing observations, and 26 complete orbits have been measured. Since half of these systems are also double-lined spectroscopic binaries, we will eventually be able to determine stellar masses for 10-15 binary systems.

The Mark III was also used, as mentioned earlier, to measure stellar angular diameters (see, for example, a paper by Mozurkewich et al. 1991, Astronomical Journal, 101, 2207). To do this, measures of fringe visibility are made using varying baselines. The fringe contrast changes are then plotted against baseline length and fit to theoretical curves for known diameters to obtain a best fit for each star observed. Data from the Mark III instrument have been used to determine angular diameters for about 50 stars with typical rms residuals of a few percent and rather good external agreement with other techniques (speckle interferometry and lunar occultations). A great advantage of interferometric techniques over lunar occultations is, of course, that occultation observations are restricted to the zodiacal region of the sky against which the Moon is seen in its orbital motion about the Earth.

For the largest angular diameter stars, which are mostly late-type supergiants such as Antares and Betelgeuse, it is also possible to measure limb darkening, which is the decrease in light intensity as one moves from the center of a star's disk toward the edge. The amount of limb darkening is dependent on both the nature of a star's atmosphere (its tenuousness) and the wavelength at which observations are made. These results can be compared with the theory of stellar atmospheres to learn more about the physical properties of stellar photospheres.

The Mark III was also used to measure the angular diameter of a nova for the first time, namely Nova Cygni 1992. This measurement, combined with the spectroscopic determination of the expansion velocity of ejected material, gave a distance estimate of 2500 parsecs, which agrees well with estimates made using other techniques.

Another interesting stellar property measured by the Mark III was the deviation from sphericity of the red variable star omicron Ceti (Mira). This was determined by measuring the fringe visibility over time and plotting the results. The asymmetry of these curves shows that Mira's disk is not spherical,

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# ABSTRACTS OF ASTRONOMICAL ARTICLES

## *By John B. Lohman and John A. Graham*

I. "How Lethal Was the K-T Impact?" - Virginia Morell in Science, 17 September 1993, p.1518.

A new analysis suggests that the impact contemporary with the Cretaceous-Tertiary (K-T) event in which the dinosaurs perished was eight times bigger than previously thought: a crater 300km wide rather than 180km. So large an impact would be unique in Earth's history since complex life began. New drilling will be needed to confirm this result.

II. "The Tunguska Event" - J. Donald Fernie in American Scientist, September - October 1993, p.412.

The Tunguska event in June 1908, in which a forest area in Siberia was devastated, was caused by the explosion of a stony meteorite 80 - 190 meters across, which had entered the atmosphere at a shallow angle. If it had struck in mid-ocean, large coastal areas on either side of the ocean would have been devastated. Such events can be expected every 2000 to 12000 years.

III. "Hubble's Road to Recovery" - Richard Tresch Feinberg in Sky and Telescope, November 1993, p.16.

NASA's whirlwind program to develop corrective optics for the Hubble Space Telescope and to make other repairs is about to reach a dramatic climax.

IV. "How We'll Fix the Hubble Space Telescope" - Jeffrey A. Hoffman in Sky and Telescope, November 1993, p.23.

A veteran space walker gives an insider's preview of NASA's extraordinary mission to repair the orbiting Hubble telescope.

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but rather an ellipse that is changing with time. Speckle interferometry measurements indicate that the angular diameter of Mira changes abruptly with wavelength as well. While Mira has a peculiar dwarf B-star companion that might have some effect on its shape, the B star is quite far away from the surface of the M star. The Bright Star Catalogue gives a parallax of 0.024 seconds of arc for Mira, yielding a distance of 42 parsecs, and the semimajor axis of the B star's orbit is 0.85 seconds of arc. Therefore, the B star is just over 2000 AU (assuming a circular orbit), or 26 times the distance of Pluto from the Sun, away from the M star. Thus, most of ellipticity of the M star is probably caused by the expansion of the M star's atmosphere and its circumstellar shell, which also causes the large variations in brightness.

Based upon the very successful results obtained with the Mark III interferometer, the collaborating institutions decided to build a second generation optical interferometer capable of making more accurate measurements of stellar positions and the other observations just described. This project began about 4 years ago and, since then, the astrometric and optical interferometer projects have been partially combined because of budgetary considerations, but it is not expected that the separate functions will be significantly compromised by this overlap. The primary goal of the astrometric interferometer is to construct a large and highly accurate catalog of stars distributed uniformly around the sky visible from Flagstaff. While this is currently being done also from observations made by the European Space Agency's Hipparcos satellite, the ground-based interferometer is expected to make observations for many decades, whereas another space mission may not take place for many years to come. The fact that star catalogs become progressively less accurate with time because of stellar space motions means that any catalog must be continuously updated with new measurements if its high accuracy is to be maintained. Of course, these remeasurements can be done with a ground-based instrument at only a small fraction of the cost of flying a space-based observatory at intervals small enough to maintain a high-accuracy star catalog.

For the remainder of his talk, Dr. Hutter described the location for the new AI and its hardware. The Anderson Mesa site, located about 15 miles southeast of Flagstaff, actually belongs to the U.S. Forest Service and is being leased to Lowell Observatory. The instrument consists of a large Y-shaped array having arms about 250 meters in length, along which the light collecting mirrors can be moved. Thus, the interferometer might be considered as a miniature version of the National Radio Astronomy Observatory's Very Large Array (VLA), which is located west of Socorro, New Mexico. Initial operations will only use the inner part of the array and will involve 22 sets of piers for the siderostats (light collecting mirrors), which can be moved around to change the baseline. The movable detectors make up the NRL part of the instrument that will be used to determine stellar angular diameters, measure binary stars, etc., while four of the stations enclosed in rolloff shelters are fixed and will be used for the USNO astrometry project. All of these stations are connected by vacuum pipes that carry the light back to a central laboratory. Each shed contains a 21-inch flat mirror of high optical quality on a pivotal mount. The astrometric stations also include additional climate-controlled chambers containing laser interferometers on reference surfaces to monitor the positions of the centers of the siderostat mirrors. Because the distances between siderostats change with temperature, and these distances must be known to high accuracy for the astrometric measurements, this elaborate laser metrology system had to be developed for the astrometric stations. The light from the array of collectors travels back to the laboratory, where it is sent to the delay lines. These delay lines are about 66 feet long and are mounted inside vacuum tanks measuring 16 inches in diameter. Each delay line consists of several movable carts on which parabolic and flat mirrors are mounted. The light is focused by the parabolic mirror and the parallel rays are reflected by the flat mirror. Each cart is movable on a set of precision rails and is controlled by a motor on another cart that is completely isolated from the optical cart. The precision delay lines are necessary to control fringe visibility in an environment where many parameters are constantly changing. Since interference fringes are observed only when the delays between the arrival of light at the various siderostats are internally compensated for within the interferometer, the precision delay lines are the most critical elements in the instrument. There are six such delay lines, of which four are used for astrometry. The light then passes through a complex set of optics that allows it to be combined from pairs of

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provide a good contrast with that given by Don Hutter at the September meeting, at which Dr. Hutter described the USNO Astrometric Interferometer that will also measure star positions.

Harold Alden Williams was educated at Florida State University in Tallahassee and at Louisiana State University in Baton Rouge, where he earned his PhD in astrophysics. Following a postdoctoral fellowship at the Carnegie Institution of Washington's Department of Terrestrial Magnetism over on Broad Branch Road, he took a position at Montgomery College in Takoma Park, where he presently teaches mathematics and physics, and directs the planetarium. Please come and join Dr. Williams and other NCA members to learn about the development and applications of astrolabes for making astronomical observations.

## *NCA WELCOMES THESE NEW MEMBERS!*

*Loren L. Booda*
*3170 North Pollard Street*
*Arlington, VA 22207*

*Caleb I. Fassett*
*(Junior member)*
*P. O. Box 321*
*Washington Grove, MD 20880*

*Gary & Alisa Joaquin*
*7821 Winona Court*
*Annandale, VA 22003*

*Seph Naficy*
*12811 Maidens Bower Drive*
*Potomac, MD 20854*

*Shahrzad Shirzad*
*10201 Grosvenor Place, #1023*
*Rockville, MD 20852*

*Steven T. Strouse*
*4237 Alabama Ave., SE*
*Washington, DC 20019-5624*

*Michael E. Taylor*
*317 S Horners Lane*
*Rockville, MD 20850*

*Barry B. Wolfe*
*6203 Stratford Road*
*Chevy Chase, MD 20815*

## Lunar Grazing Occultations This Month

*submitted by David Dunham*

| Date | Day | EST | Star | Mag | Sp | % | CA | alt | Aper. | Location |
|---|---|---|---|---|---|---|---|---|---|---|
| Nov 7 | Sun | 2:25 | 1359 | 5.2 | B9 | 49- | 2S | 33 | 2 | Chester, VA |
| Nov 22 | Mon | 22:18 | 3453 | 4.9 | A0p | 69+ | 8S | 36 | 2 | Hickory, VA |
| Nov 29 | Mon* | 0:58 | 0633 | 5.4 | B8 | 3E | 37 | 71 | 1 | St. Pauls, NC |
| Nov 29 | Mon* | 1:05 | 076550 | 8.7 | F5 | 0E | 31U | 66 | 4 | Glenn Rock, PA |
| Nov 29 | Mon* | 2:14 | 0642 | 5.4 | B8 | 28E | 37U | 71 | 1 | Hamburg, NY |

*3 possibilities during total lunar eclipse, see chart

## Asteroidal Occultations/Appulses This Month

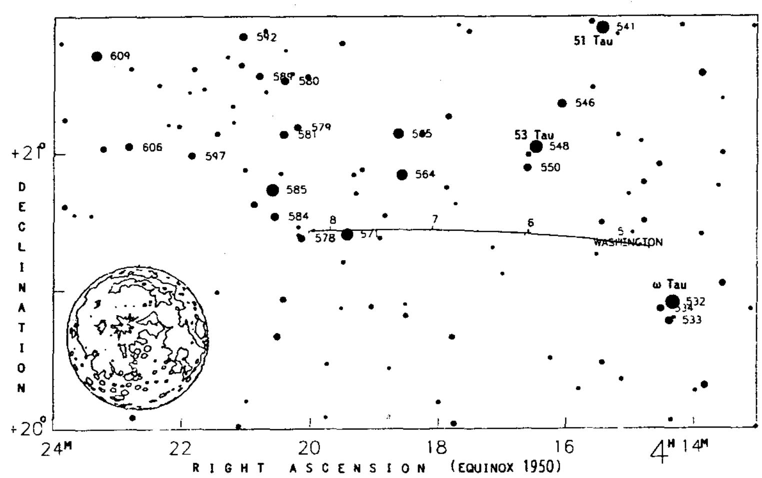
| Date | Day | EST | Star | Mag | Sp | alt | Aper | Location | Asteroid |
|---|---|---|---|---|---|---|---|---|---|
| Nov 22 | Mon | 21:32 | 164056 | 8.7 | G5 | 6 | 4 | nwOhio | (19) Fortuna |
| Nov 23 | Tue | 1:33 | Anon. | 12.3 | | 61 | 8 | s.Georgia | (1220) Crocus |

For more information and for joining the expedition(s), call David Dunham on 301/474-4722 or 953-5609. Occultation recorded message: 301/474-4945

# Eclipsed Moon in the Hyades

***By David Dunham***

During the night of November 28-29, 1993, the totally eclipsed Moon will lie in the northern part of the Hyades shown on the chart. The path of the Moon's center is shown for Washington, DC. Upward ticks mark integral hours of Universal Time. Downward ticks mark the four umbral eclipse contacts from right to left; see the article about the lunar eclipse in the November issue of Sky and Telescope for their times. The Moon figure provided by Bob Bolster is oriented correctly, but not positioned. Cut out a copy of the figure and move its center along the path, preserving its orientation. This should allow the prediction of disappearance and reappearance times to within a few minutes, as well as an estimate of where on the Moon's limb the events will occur.




The faintest stars shown on the map are magnitude 11.5. The brighter stars are in the Smithsonian Astrophysical Observatory (SAO) Star Catalog. Add 76000 to the plotted number to obtain the star's SAO number.

The eclipse provides an excellent opportunity to time occultations completely around the Moon's disk. Such timings are important for lunar profile studies, as discussed on p. 75 of last January's issue of Sky and Telescope. That article also has a map showing five grazes of bright stars that occur during the eclipse in North America and includes information about stellar duplicity.

Information about expeditions and weather updates is available on the occultation line at 301-474-4945. Those planning programs to time occultations with large telescopes can request report forms and detailed predictions at that number. Accurate geographical coordinates, including height above sea level, are needed.

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collectors so that fringes can be observed. The measured amounts of delay compensation and the known baselines are then used to determine the exact direction of the target star.

The operation of the full array, not expected for about 5 years, will allow the construction of synthetic images of stars by use of an even more complicated beam combining system. Dr. Hutter showed some models of such stars constructed from a hypothetical ten-siderostat system. He then showed some slides of the construction site and partially completed parts of the new interferometer. He stated that the goal of the project is to begin making observations in December of this year, with full astrometric operation commencing in 1994 June. Although full imaging capability is several years away yet, preliminary observations of stellar diameters, limb darkening, and binary stars are expected to begin next Spring sometime.

Dr. Hutter concluded his presentation by expressing appreciation for the Navy's support for the construction of the new optical interferometer and by noting that many new results that will further our knowledge concerning the structure of our Galaxy and the astrophysics of the stars are certain to come from this versatile instrument.

# AMERICAN ASTRONOMICAL SOCIETY MEETS IN WASHINGTON

***John Graham***

The American Astronomical Society will hold its next semiannual scientific meeting on January 11 through 15, 1994. This meeting will be held at the Crystal Gateway Marriot Hotel in Arlington, Virginia (the site of the January 1990 AAS meeting), which is directly over the Crystal City subway station, just north of National Airport and across the Potomac from downtown Washington. The theme for this meeting is "The State of Astronomy as Seen from Inside the Beltway". All interested in astronomy are invited to register and attend. The registration fee for the meeting is $125 for AAS members and $150 for non-members, for registration received before December 17. However, volunteers assisting with the meeting logistics by providing 2 days' (plus half-day standby) assistance with audio-visual equipment, registration or similar tasks, will be registered for the entire AAS meeting at no cost.

The winter AAS meeting is always impressive, attracting as it does more than 1000 astronomers from all parts of the country. The Washington meeting has traditionally been very large. It is rather a fun occasion as there is lots going on. In Washington, there is generally a fairly strong emphasis on Science Policy in Government. Last time we had a special address from Vice President Dan Quayle. Many exciting invited talks are scheduled. Presentations will be given, for example, on the Messier 81 supernova, Astronomy and State: US and Soviet/Russian Perspectives, South Pole Astronomy, and the Latest News from the Big Bang as seen by COBE. It is well worth attending if you can manage it.

If you are interested in volunteering, please fill out the coupon below and mail it to Dr. Robert Hindsley at the U.S. Naval Observatory. You will be contacted by return mail by mid-December. An orientation meeting for volunteers will be held Monday January 10 at the Crystal Gateway Marriot; lunch will be provided.

More information on volunteering may be obtained by calling Dr. Hindsley at (202)653-0951 during the day or (301)345-8967 in the evenings. He may also be reached by e-mail (Internet) at rbh@crux.usno.navy.mil. Information about the meeting itself is available from the AAS Executive Office, 1630 Connecticut Avenue, NW, Suite 200, Washington DC 20009.

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(Tear off here)

Yes, I am interested in volunteering to help at the AAS meeting in January.

| | | | |
|---|---|---|---|
| Preferred Days: | Tuesday | January 11 | Please circle the days that |
| | Wednesday | January 12 | you would prefer, and cross |
| | Thursday | January 13 | out any days that you definitely |
| | Friday | January 14 | cannot help. |
| | Saturday | January 15 | |

I am interested in the following areas of astronomy ______________________________

____________________________________________________________

NAME: ______________________________

ADDRESS: ____________________________________________

____________________________________________________________

____________________________________________________________

DAYTIME PHONE NUMBER: ______________

E-MAIL ADDRESS (if available): ________________

MAIL TO: Dr. Robert Hindsley
Astrometry Dept.
U.S. Naval Observatory
3450 Massachusetts Ave NW
Washington, DC 20392-5420

OR rbh@crux.usno.navy.mil

(E-mail is encouraged if you have access)

YOU DO NOT NEED TO SEND IN A SEPARATE MEETING REGISTRATION FORM!

# National Capital Astronomers, Inc.

is a non-profit, public-service corporation for advancement of the astronomical sciences and is the astronomy affiliate of the Washington Academy of Sciences. For information, call NCA: (301) 320-3621.

**SERVICES AND ACTIVITIES:**

**A Forum** for dissemination of the status and results of current work by scientists at the horizons of their fields is provided through the monthly NCA Meeting. (See monthly *Stardust* for time and location.) All interested persons are welcome; there is no charge.

**Expeditions** frequently go to many parts of the world to acquire observational data from occultations and eclipses which contribute significantly to refinement of orbital parameters, the coordinate system, navigation tables and timekeeping. Other results of this work under continuing study include the discovery of apparent satellites of some asteroids, discovery of apparent small variations in the solar radius, and profiles of asteroids.

**Discussion Groups** provide opportunities for participants to exchange information, ideas, and questions on preselected topics, moderated by a member or guest expert.

**Publications** received by members include the monthly newsletter of NCA, *Star Dust*, and an optional discount subscription to *Sky & Telescope* magazine.

**The NCA Public Information Service** answers many astronomy-related questions, provides predictions of the paths and times of eclipses and occultations, schedules of expeditions and resulting data, assistance in developing programs, and locating references.

**Astronomical Telescope & Binocular - Public Seminar,** for Selection, Use, and Care, held annually in November, offers the public guidance for those contemplating the acquisition of a first telescope, and dispels the many common misconceptions which often leads to disappointment.

**Working Groups** support areas such as computer science and software, photographic materials and techniques, instrumentation, and others.

**Telescope-Making Classes** teach the student to grind and polish, by hand, the precise optical surface that becomes the heart of a fine astronomical telescope.

**NCA Travel** offers occasional tours, local and world-wide, to observatories, laboratories, and other points of interest. NCA sponsored tours for comet Halley to many parts of the southern hemisphere.

**Discounts** are available to members on many publications, products, and services, including *Sky & Telescope* magazine.

**Public Programs** are offered jointly with the National Park Service, the Smithsonian Institution, the U.S. Naval Observatory, and others.

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If family membership, list names of additional participating immediate family members in same household, with birthdates of all those under 18 years old: ______________________________

**Note:** If you already subscribe to ***Sky & Telescope***, please attach a recent mailing label. You may renew this subscription through NCA for $22 when it expires.

Make check payable to National Capital Astronomers, Inc., and send with this form to:

Leith Holloway 10500 Rockville Pike Apt. M-10, Rockville, MD 20852.

The following information is optional. Please indicate briefly any special interests, skills, vocation, education, experience, or other qualifications which you might contribute to NCA.

Thank you, and welcome!

______________________________________________________________

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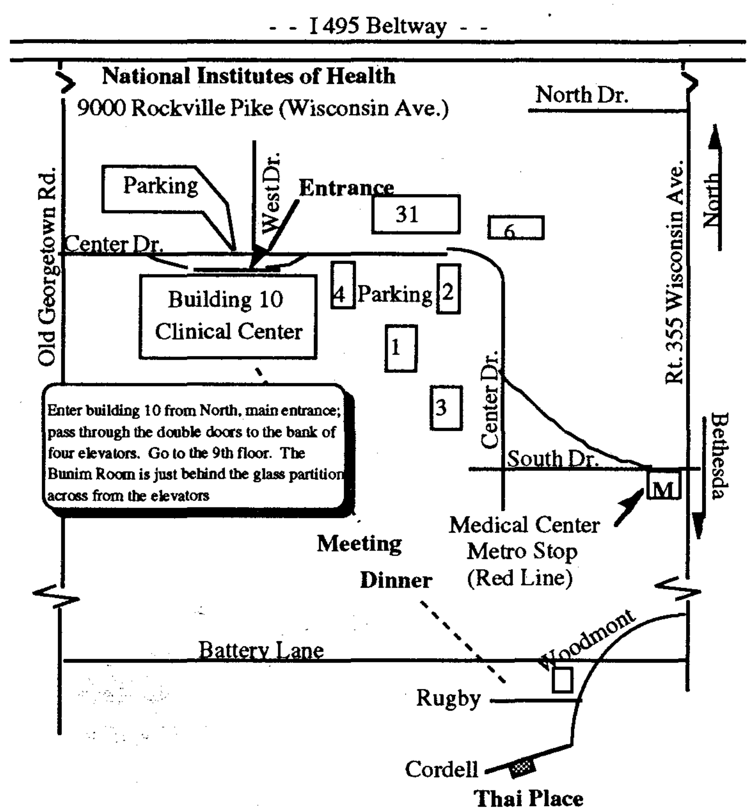
# Getting to the NCA Monthly Meeting

•Subway Riders - From Medical Center Metro Stop: Walk down the hill, pass the bus stops and turn right at the anchor (onto Center Drive). Continue uphill to building 10, the largest building on campus. Also, the J2 bus line connects the Bethesda (7:16 PM) and NIH (7:23 PM) Metro stops with Building 10 (7:25 PM).

•To Thai Place Restaurant: Proceed down Wisconsin Avenue toward Bethesda. Bear right onto Woodmont (or the next right onto Battery Lane), follow Woodmont across Battery and Rugby, take a right onto Cordell and park. The restaurant will not guarantee seats after 5:30.

***Stardust* is published ten times yearly (September - June) by National Capital Astronomers, Inc. (NCA), a non-profit, public-service corporation for advancement of astronomy and related sciences through lectures, expeditions, discussion groups, conferences, tours, classes, public programs, and publications. NCA is an affiliate of the Washington Academy of Sciences. President John Graham. Deadline for *Stardust* is the 15th of the preceding month. Editor Nicoletta Stephanz, 202/332-7756. NCA Phone Number is 301/320-3621.**




**National Capital Astronomers, Inc.**
c/o Nicoletta Stephanz
1511 17th Street, NW #5
Washington, D.C. 20036

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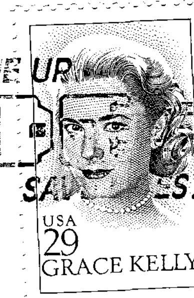


BUCKLE UP ... SAVES LIVES!

Exp. 3/31/94
Dr. Wayne H Warren, Jr
8001 Brett Place
Greenbelt MD 20770-3001



20770-3001 05