Star Dust

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Mario Acuña to Talk on Neptune's Magnetic Field and Magnetosphere

By Nancy Byrd

The next meeting of National Capital Astronomers is April 3, 1993 at 7:30 PM, at the National Institutes of Health (in the Bunim Room on floor 9 of the Clinical Center, Building 10). At this colloquium, we are honored to present Dr. Mario H. Acuña of NASA Goddard SpaceFlight Center, who will talk about very interesting and poorly known discoveries which have resulted from the Voyager missions, on the nature of Neptune's magnetic field.

As Dr. Acuña writes, the Voyager spacecraft have provided us with exceptional opportunities to explore the outer planets of the solar system with an advanced complement of instruments capable of a wide range of remote and in-situ measurements. Although most people relate immediately to Voyager's well known discoveries through the images obtained with their TV cameras, the knowledge derived from the "fields and particles" instruments is equally vast and relevant. In particular, the determination of the existence of magnetic fields of internal origin, in all of the planets visited, is a major step forward in our understanding of the outer solar system. These fields also trap energetic charged particles and plasmas which in turn give rise to a variety of phenomena which we are still trying to decipher from the data. Neptune and Uranus are unique in terms of the complexity of their magnetic fields which give insight into the processes that may be taking place in their interiors. The talk will review some of Voyager's previous observations at Jupiter and Saturn to put them in context with respect to the Neptune discoveries. The interaction of moons and rings with trapped particles and how they can be used to perform "charged particle astronomy observations" in different planetary environments will also be covered in some detail to help understand the Voyager observations.

Dr. Acuña currently serves as US project scientist for the International Solar Terrestrial Physics program, a joint international research effort by Japan, Europe, and the United States, involving more than 1,000 investigators. Dr. Acuña has participated in the Explorers 47 and 50 missions, Mariner 10, Pioneer 11, Voyagers 1 and 2, and the International Solar Polar mission (currently ULYSSES) as principal investigator, co-investigator, project scientist or instrument scientist. In 1986, he was selected as principal investigator for the Mars Observer Magnetic Field Investigation. In addition, he has published extensively on subjects as planetary exploration, magnetic fields and plasmas in the solar system. He has been honored by NASA and other organizations with numerous awards including the Medal for Exceptional Scientific Achievement, the Exceptional Service Medal, and the Award of Merit in recognition for his contributions to engineering, physics and space research.

Born in Cordoba, Argentina, Dr. Acuña earned his MS degree in Electrical Engineering from the University of Tucman, Argentina in 1967 and his Ph.D. in Space Science in 1974 from Catholic University in Washington, DC.

April Calendar

The Public is Welcome!

Saturday, April 3, 9:30 AM - David Lavery (NASA), "NASA, Robots, and the Inferno." At The Smithsonian Institution, National Air and Space Museum (NASM), Albert Einstein Planetarium.

Saturday, April 3, 5:30 PM - Dinner with the speaker at Frascati's Restaurant in Bethesda before the monthly meeting. Reservations are for 5:30 Sharp!

Saturday, April 3, 7:30 PM - Dr. Mario Acuña: "Neptunes Magnetic Field and Magnetosphere." 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.

Tuesday, April 13, 5:45 PM - George Smoot, "Primordial Seeds of Modern Structure in the Universe." At The Carnegie Institution of Washington, Carnegie Auditorium. For details, call 202/328-6988.

Saturday, April 17 - Sunday April 18 - NCA "Dark Sky Observing/National Radio Astronomy Observatory Tour" to West Virginia. For details, call Sue Bassett at 410/792-2943.

Wednesday, April 21, 7:30 PM - Daniel Costanzo (NCA), "Make Every Night Earth Night." At The National Wildlife Federation, Vienna, VA (April meeting of The Sierra Club, Northern Virginia Chapter). For details, call 703/841-4765.

Thursday, April 29, 7:00 PM - Daniel Costanzo (NCA), "Astronomy O!O!O!: Life, The Universe, And Everything" (four week adult education course), at Arlington Planetarium. For details and cost, call 703/358-6070.

Friday, April 30 - Last chance to view Galileo's original Sunspot drawing (made 1612), in the exhibit "Rome Reborn: The Vatican Library and Renaissance Culture," at The Library of Congress. For details, call 202/707-5458, and see *Sky & Telescope*, 1993 March, p. 34. Don't miss this unprecedented opportunity!!!

Tuesday, April 5, 12, 19, 26, at 7:30 PM - Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

Friday, April 2, 9, 16, 23, 30, at 7:30 PM - Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

Friday, April 2, 9, 16, 23, 30, 8:30 PM - Open nights with NCA's Celestron-14 telescope open nights with Bob Bolster, 6007 Ridgeview Drive, south of Alexandria off Franconia Road between Telegraph Road and Rose Hill Drive. Call Bob for details and more dates at (703) 960-9126.

Next Month:

Saturday, May 1, 7:30 PM - Dr. Goetz Oertel, "The AURA Gemini Project."

Abstracts of Astronomical Articles

By John B. Lohman & John A. Graham

I. "The Center of the Milky Way" - Leo Blitz et al. in *Nature*, 4 February, pp. 417-424.

Direct photometric evidence has established that the central bulge of our Galaxy (the Milky Way) is actually a stellar bar. The dynamics of the bar will drive material into the Galaxy's center but recent X-ray observations suggest that much of the inflowing gas is driven out again in a high pressure wind. A small portion of the remainder appears to be falling onto an extraordinarily dense cluster of stars at the Galaxy's nucleus which may contain a massive black hole.

II. "NASA Stakes Its Reputation on Fix for Hubble Telescope" - Faye Flam in *Science*, 12 February, pp. 887-889.

In December, a space shuttle will retrieve the Hubble Space Telescope for planned maintenance and update - and to correct its flawed primary mirror. The operation is being planned and practised extensively, and is not without risk. A mishap could cripple the instrument entirely. All of the telescope's instruments are presently degraded by the flawed mirror; the Faint Object Camera and the Wide Field Planetary Camera most severely. The changes will affect some instruments' characteristics. The new wide field camera will span a field only three quarters that of the old one. It will take several months of engineering adjustments to line up the telescope's instruments again.

Also note the following articles in the April issue of *Sky and Telescope*: "Hubble Repair Under Review" p. 8; and "Hubble Telescope Loses Another Gyro" pp. 11 - 12.

III. "Evolution of Atmospheres" - A series of articles in *Science*, 12 February, pp. 905-941.

These articles are primarily on geology, but have astronomical aspects. Mercury, Venus, Earth, and

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JAMES CROWLEY DISCUSSED IMAGING SPECTROMETER STUDIES OF EARTH AND BEYOND

By Daniel J. Costanzo

New remote sensing instruments called imaging spectrometers are an exciting and rapidly evolving technology, with numerous applications for studying Earth and beyond. At our March colloquium, James Crowley (U.S. Geological Survey) gave a "mini-short course" on this subject concerning Earth and other Solar System objects. Jim currently is a geologist at the USGS's Reston, VA Headquarters, specializing in geological remote sensing, sometimes called "spectral geology." His presentation offered a unique perspective on things by looking down from space at the ground for a change, instead of looking up at space from the ground, although both harness the electromagnetic spectrum (EMS) for studying objects and phenomena.

Every digital, remotely sensed image (also called a scene) of any world's surface captures electromagnetic energy coming from that surface. This energy, when gathered by the sensor, is converted into image data as picture elements (pixels) at four fundamental resolutions: spatial, spectral, radiometric, and temporal. Spatial resolution defines how small an area of surface each of the image's pixels cover (i.e. their "footprint"). Spectral resolution is how narrow a band (also called a channel) of EMS the sensor captures from that surface. Radiometric resolution is how well the sensor differentiates the amount of energy (i.e. brightness values) received from the spot of surface covered by each pixel. Finally, temporal resolution is how often a sensor can capture data (i.e. pixels) over a surface (necessary for studying variations over time).

Unclassified digital remote sensing of Earth had its origins in robotic exploration missions to the Moon and beyond. The most famous Earth sensing systems, the Landsat-type Earth orbiting satellites, capture data in a relatively small number of rather broad spectral bands centered on different visible to near-infrared (VNIR) wavelengths. Airborne imaging spectrometers (AISs), like NASA's Airborne Visible-Infrared Imaging Spectrometer (AVIRIS), however, provide detailed spectral information about celestial objects, Earth included, in hundreds of narrowly spaced spectral channels (224 for AVIRIS). AISs offer the same and better spatial resolution of Landsat-type broad-band sensors, but with a laboratory bench spectrometer's spectral resolution. For Earth sensing, AISs like AVIRIS provide detailed spectral information over the VNIR wavelength range (0.4-2.5 micrometers (um)). Their significantly greater spectral resolution opens up whole new ways to study Earth and beyond.

AVIRIS is generally flown at an altitude above Earth's surface of approximately 20 kilometers (km) (70 000 feet) aboard NASA U-2 and ER-2 aircraft designed for civilian remote sensing. From that altitude, with its linear sensor array, AVIRIS scans a swath of surface below, simultaneously forming a two-dimensional image in each spectral band with pixels having a 20 meter (m) spatial ground resolution. Its acquired data set can thus be thought of as an "image cube" consisting of 224 individual images, each an image of the ground in a particular spectral band. Alternately, these data can be thought of as a single spatial image, for which there is a rather detailed VNIR spectrum associated with every pixel. Database volumes from AISs are quite large compared to other remote sensors. For example, AVIRIS generates almost one gigabyte of digital data in a single scan covering a 60-70 km portion of Death Valley, California. And when compared to laboratory spectra, AVIRIS spectra generally are noisier, i.e. they has a lower signal-to-noise (S/N) ratio than laboratory spectra of samples of the same materials or combinations of materials. But even so, AVIRIS data can nicely track with laboratory spectra of particular minerals and other surface materials.

The VNIR and mid-infrared (MIR) wavelength regions are useful for Earth remote sensing for two reasons. First, because "light" (i.e. electromagnetic energy) at these wavelengths interacts strongly with matter, but not so strongly as to disrupt that matter's chemical bonds. As a result, minerals, rocks, soils, vegetation canopies, and other surfacial features exhibit potentially diagnostic spectral features in VNIR and MIR wavelength ranges. The second reason is there are "windows" in Earth's atmosphere at these wavelengths permitting remote sensing observations of Earth's surface. Obviously, restrictions by atmospheric windows are less of a constraint for remotely sensing some other Solar System bodies, e.g. Mars. However, the first factor — the nature of interactions between light and matter, is still important.

There's a lot we just don't understand about sources of spectral variation in the spectral curves we observe

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in nature, both for materials on Earth and other worlds. We just don't know the meaning of many aspects of spectral variability we can see in the data our sensors capture for us, thus leaving a great deal to be learned. However, we do know that spectral features of surficial materials in VNIR and MIR originate from different molecular groups producing different absorption characteristics in spectra. With minerals, spectra of various "mineral species" can indeed take on great complexity as some minerals contain different molecular groups, contain duplicate groups in different structural sites, or vary across compositional gradients. The spectral resolution of a broad-band scanner like Landsat's Thematic Mapper (TM) is still just too coarse to differentiate them. But with an AIS like AVIRIS, they can be separated into different "species."

A perfect imaging spectrometer produces a total radiance measurement for every pixel. In VNIR and MIR, this has the overall shape of the solar blackbody curve from solar irradiation of Earth (called the Solar radiance curve), with several added components (i.e. signals). These include a ground reflection component from reflection by surface materials covered by each pixel, an atmospheric absorption component from absorption by atmospheric gases in the air column above each pixel, and a scattering component from scattering by atmospheric aerosols in that same air column. The signal from the ground is what the geologist is interested in. But all these components (i.e. signals) are mixed together and must be deconvoluted (i.e. separated), from the total radiance signal the sensor captures for each pixel. Fortunately, the total radiance measurement contains the seeds of its own destruction, or at least of its own spectral deconvolution. Through estimating via atmospheric modeling, the air column's spectral contribution to the total radiance can be calculated and removed from each pixel, thus facilitating observation of spectral features from soil, rock, and vegetation.

When AVIRIS was being designed and first used, there was a lot of skepticism about why such a wide range of wavelengths was needed for remote sensing. Skeptics thought that only a few, selected spectral bands were thought to contain most of the important data. But researchers, much to the surprise of many, are finding a use these days for just about the full wavelength range AVIRIS provides. However, with imaging spectrometers, subtle differences in spectra can be exploited only by becoming "a renaissance type person" of sorts. That is, you can get at one thing only by understanding all other things at work in and on objects and phenomena you are trying to understand. For example, with remote sensing of plants, to know what tree species you are looking at, you have to understand the whole signal, i.e. you need to know spectral characteristics of the types of soil (e.g. the mineral components) the tree is growing in, etc. In essence, concentrating only on the trees misses not only the forest, but a whole lot more. Jim gave several examples of this by illustrating diverse applications in imaging spectrometry for studying Earth's land surface and atmosphere in VNIR and MIR wavelengths. These are briefly summarized below.

Atmospheric phenomena, though an annoyance to geologists, are important in studying energy transport and climatic processes. Thus, AISs' high spectral resolution can also serve as "atmospheric sounders" looking at different levels of Earth's atmosphere. Atmospheric sounding involves looking down at Earth using different spectral ranges, each tuned to probe atmospheric features at different levels above the ground, e.g. spotting cirrus clouds' global distribution, or measuring temporal variations in water vapor. But in this case, instead of removing the atmospheric component of a pixel's total radiance value, that component is specifically looked for.

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Mars have atmospheres which are quite different today but most likely had similar initial compositions. Our atmosphere permitted the development of life, which then greatly changed it. Mars may have experienced dramatic climatic changes: large floods, perhaps transient oceans. Study of this history is a main objective of the Mars Observer spacecraft, which is now en route to Mars.

IV. "Stabilization of the Earth's Obliquity by the Moon" - J. Laskar, F. Joutel and P. Robutel in *Nature*, 18 February, pp. 608-612; 615-616.

Numerical study of the global stability of the spin-axis orientation (obliquity) of the planets against secular orbital perturbations shows that all of the terrestrial planets could have experienced large, chaotic variations in obliquity at some time in the past. The obliquity of Mars is still in a large chaotic region and is liable to radical change. Mercury and Venus have now been stabilized by tidal dissipation from the Sun. The presence of the Moon appears to stabilize the obliquity of the Earth. Thus, the long-term stability of the Earth's climate and the development of advanced life may depend on the presence of the Moon. This should be taken into account when estimating the probability of finding a planet around a nearby star with a climatic stability comparable to that of the Earth.

FROM THE SECRETARY

This is a reminder for those whose NCA membership expires on August 31, 1993. I will be mailing out your renewal bills at the end of this month. There are 53 members having an August expiration date, and the cost of mailing this number of bills is substantial. You can save the NCA the cost of billing, if you send me your dues soon after your *Sky & Telescope* renewal notice comes in the mail at the end of this month.

If you desire to continue your subscription to *S&T*, please send me a check for $46 made out to the NCA along with the S&T renewal notice (3.5 by 8.5-inch card). If you elect to rejoin the NCA without the *S&T* subscription, you need to send a check for only $24. If you decide not to rejoin the NCA, you may do nothing, but I would appreciate hearing from you so that I do not need to send you a bill. When you renew, please confirm that we have your correct address and telephone number(s) and that you have been getting membership cards for all in your family who desire them. Check your mailing label on *Star Dust* and/or your listing in the NCA directory for this information. Thank you very much.

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AISs like AVIRIS can serve as "remote sensing probes" for biogeochemistry studies, especially in remote observation of vegetation canopies. Researchers would like to make large scale measurements usable for studying biochemical cycling, ecosystem dynamics, and responses of ecosystems to environmental change. This includes making quantitative measurements of leaf chlorophyll content and relating them to photosynthetic activity and carbon fixation. With vegetation however, the big challenge is to detect all these components in a green leaf. Vegetation (i.e. leaf), spectra are all rather similar, and tend to be dominated by liquid water absorption bands (after all, Earth life is mostly just bags of liquid water). AISs can differentiate very subtle differences in these spectral shapes (i.e. invisible to the human eye looking at leaves) for making biogeochemical measurements and mapping their spatial distribution as inputs into computer models.

The central theme running through just about all imaging spectrometer research is how to deal with subpixel mixtures, i.e. different surfaces combining to produce a response in a pixel. "Linear spectral unmixing" addresses this problem by considering the total spectrum for each pixel to be a sum of separate spectra, allowing you to sort of "bootstrap" your way into different spectral components. Algorithms have been developed to find the best fit solution using this technique, given a selection of candidate endmembers as input from a preexisting "spectral library." Results of linear spectral unmixing can be displayed as a series of "fraction images," each showing the spatial distribution of a single spectral endmember, e.g. areas containing rhyolite, oxidized volcanic cinders, or both on an AVIRIS image of Lunar Craters Volcanic Field in Nevada.

Cuprite, Nevada is a favorite geologic remote sensing test site, including for testing image processing algorithms. With AVIRIS data for Cuprite a "band-fitting algorithm" technique was applied. Basically, the objective was to take imaging spectrometer data and have reference spectra "compete" with each other - e.g. each pixel in the scene is assigned to a single reference surface material based on its best fit to the spectrum for that pixel. The "goodness" of the fit can also be measured. This approach is especially suitable for mapping subtle changes in spectral band shapes with somewhat noisy data. It does not, however, deal with subpixel mixtures, except as they are explicitly defined by including "mixed" spectra along with the other reference spectra in a mapping run.

Given its intense study, one would think that everything would be known about Cuprite, Nevada by now. What's so intriguing are new ideas being generated about its morphology, from examination with AVIRIS. One interesting result was the possible discovery of an "alunite spectral-geothermometer" there. Apparently, this mineral displays a distinct spectral feature as it is subjected to increasing temperatures, though the mechanism causing this is not particularly clear. But, we can map, via AVIRIS, spatial distributions of minerals in sites like Cuprite, though we don't necessarily understand the color-

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ful blobs we are seeing as subtle spectral phenomena on these images. But it is all leading to a point where we can see the spatial distribution of things, e.g. mineral species, and try to find an explanation of these patterns. This work has even led to development of a new Cuprite structural model involving a low angle fault. This explanation is all the more surprising since the Cuprite site is considered so well documented that everything major has already been learned and explained about this site. All of these matters need further study, but nonetheless, demonstrate the "synergy" involved in making new discoveries.

Evaporite deposits in playas like those in Death Valley, California are natural laboratories for studying the chemistry and evolution of salt minerals and groundwater. Playa deposits are also major sources of industrial chemicals. But "to the naked eye," looking either on the ground or from above, their salt crusts have a vast extent and rather nondescript appearance. In fact, playas are very difficult to study with conventional field methods because it is hard to know where to collect samples, and their chemical composition can be quite varied. AVIRIS data was recently collected over Death Valley, and analyzed by Jim to display "mineral maps" of the playa areas. The occurrence and distribution of these surface minerals appears to tell us something about the inflow characteristics and "plumbing system" there. Analysis also indicates that there might be a subsurface magnesium ore deposit. The way to find out would be to collect some drill core samples. However, owing to its location in a National Monument, immediate prospects of drilling are not very good. So for the moment, we can only speculate about buried mineral deposits, and do quite a lot of remote sensing.

Death Valley is a rather simple test site in that it has little vegetation, and the salts there are pretty consistent over relatively large spatial areas. This all provides a relatively easy time of figuring out surface composition via remote sensing. What AIS's haven't quite dealt with yet are very complex objects and phenomena, e.g. cities with all their different, varying surfaces and atmospheric aerosols. AIS's also are being adapted for ocean sensing, e.g. for turbidity measurements, though oceans tends to be rather dark in most wavelengths. And though a planned imaging spectrometer was canceled from NASA's Earth Observing System (EOS), one could be orbiting Earth some time in the near future for global change studies.

TRANSCRIBER'S NOTE: Though not carrying imaging spectrometers, Landsat spacecraft revolutionized the way we look at Earth. To celebrate the 20th anniversary of the first Landsat launch in 1972, an exhibit, "Landsat: Monitoring Earth's Environment," is on display at The Library of Congress through June 20. For details, call 202/707-5458. NASM's "Looking At Earth" exhibit is another fine, permanent display on remote sensing. Both show that Earth, when viewed from space, is indeed the most beautiful of all known planets.

Experience gained working on Earth will be crucial for understanding future imaging spectrometer observations of other celestial objects. For one thing, on Earth we can usually go out and collect samples to help us understand the remote sensing data we capture. Clearly it is harder, if not impossible to do this for other worlds. But two instruments qualifying as imaging spectrometers are currently onboard as payloads of operational planetary space probes: Mars Observer and Galileo.

Onboard Mars Observer is TES - Thermal Emission Spectrometer. It will collect data in the MIR. But we have relatively little remote sensing experience on Earth in this wavelength range because of our Blue Planet's thick atmosphere. But the Red Planet doesn't suffer from this problem. Nor is there any vegetation to deal with. The plan is to image Mars' entire surface at a spatial resolution going down to 3 km at best. TES may provide some unique answers about Mars, but it won't be a matter of straightforward interpretation when these images come back. However, if we are able to completely decipher the compositional information from TES, we may come to know more about Mars' surface composition than we know about Earth's (Maria Zuber (NASA, Goddard Space Flight Center) described the Mars Observer Laser Altimeter (MOLA) at NCA's 1990 September Colloquium).

Onboard Galileo is NIMS - Near Infrared Mapping Spectrometer. NIMS is very similar in capabilities to AVIRIS; it covers the 0.7 to 5 um region. It should be well suited for mapping variations in ice composition on all Jupiter's Galilean satellites, different sulfur phases on Io's surface, and cloud features of Jupiter. NIMS's spatial resolution will be around 25 km at best. Unfortunately, NIMS produces voluminous data sets, meaning there will be data transmission difficulties given Galileo's continuing high-gain antenna deployment problem. But, perhaps in a couple of years, NCA will be able to hear a talk on imaging spectrometer results from these two instruments.

Jim noted that he had NCA to thank for getting him initially interested in science. He joined it in 1966 as a Junior member, and built a telescope, under the tutelage of Jerry Schnall, in one of NCA's telescope making classes. And he has maintained a continuous membership in NCA to this day. Responding to the question of, without NCA, would he be doing what he is doing today, Jim responded, "...I'd probably be selling insurance...I have to give NCA credit for helping start me along the path, whatever it is..." So he can say he came "full circle" with this presentation, although it was geology instead of astronomy that he earned a doctorate in. He specifically credited his early exposure to NCA's unique synthesis of space technology, astronomy, and related sciences in making him aware of these disciplines' unified nature. And NCA emphasized how remote sensing bridges them as a fundamental tool toward understanding Earth's connection to a much vaster Cosmos.

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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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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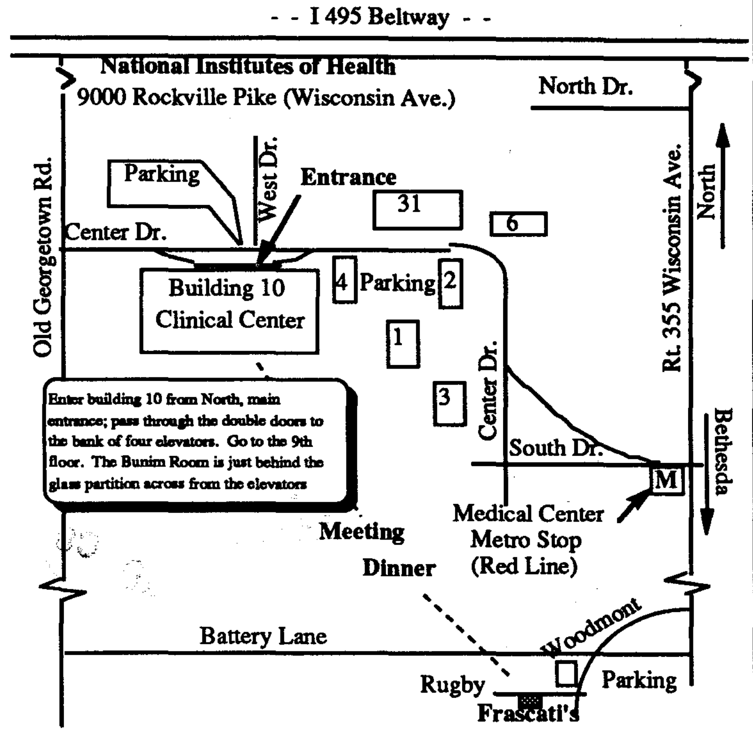
Getting to the NCA Monthly Meeting

•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 Frascati's: Proceed down Wisconsin Avenue toward Bethesda. Bear right onto Woodmont (or the next right onto Battery Lane), follow Woodmont across Battery, take a right onto Rugby 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.**



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