Star Dust

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New Views of Protoplanetary Disks

Submitted by Nancy Byrd

At the Saturday, December 4 meeting of National Capital Astronomers (NCA), Dr. Carol Anne Grady of NASA Goddard Spaceflight Center be the featured speaker. The meeting will take place at the Lipsett Auditorium in the Clinical Center (building 10) of the National Institutes of Health at 7:30PM. Her lecture is titled, "New Views of Protoplanetary Disks." Dr. Grady submits the following abstract of her talk:

"Until recently, studies of the formation of planetary systems were the purview of theorists and those studying the meteoritic fossil record for our Solar System. All this has changed with recent ground based and Hubble Space Telescope studies of star and planetary system formation. Direct imaging of the disks and environments of very young stars has been carried out with the Wide Field and Planetary Camera/2 (WFPC/2). To image the disks around older, less heavily embedded stars coronagraphic observations, where the star and its immediate vicinity are occulted are needed. Such studies have been carried out in the near-infrared by the Near-Infrared Camera and Multi-Object Spectrograph (NICMOS), as part of that instrument's investigation definition team's Environments of Nearby Stars program, and by the Space Telescope Imaging Spectrograph (STIS). I review the results of the WFPC/2 and NICMOS studies, and present the first results of the on-going STIS survey of 1-10 million year old intermediate-mass stars, focussing on the data for AB Aur and HD 163296."

We've all seen the stunning photos of young star systems. But what can we learn from these data? Dr. Grady will help us to find out. O

Design of Modern Space Actuators
Review of November Lecture

by Richard J. Byrd

Introduction

For the November meeting of National Capital Astronomers, John Vranish of the Goddard Space Flight Center regaled us with a lecture unlike the presentations usually given. Most of NCA talks present the results of scientific data gathered in space or by land-based observations. However, this lecture explained some details of the engineering behind the science. Mr. Vranish explained in detail the design of some of the esoteric hardware that enables a spacecraft to fly and complete its mission.

An eminent electromechanical designer, Mr. Vranish is a holder of over thirty patents, and has been selected three times as the inventor of the year by the Goddard Space Flight Center. He was the 1997 IR 100 award winner for being one of the 100 best inventors in the world, as selected by R&D Magazine.

Mr. Vranish developed the first active sonic bearing, ultrasonic wave motor, tested successfully in 1998. He also designed a ratchetless wrench mechanism for NASA which has been used in space. At our meeting he described two of his actuator designs. Space actuators are small devices which must mechanically move another device with great resolution and precision. These "gadgets," as Mr. Vranish calls his actuators, are for use in the Next Generation Space Telescope (NGST).

Precision Screw Slide

The first actuator which he described, was a long-stroke, cold-temperature actuator built to meet very difficult design parameters. This device, which Mr. Vranish called a Precision Screw Slide, had to move an output ram some six millimeters of total movement with a resolution of better than 25 nanometers

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Calendar of Monthly Events

The Public is Welcome!

NCA Home Page: http://capitalastronomers.org

Fridays, December 3, 10, 17, 24, and 31, 7:30 PM - Telescope making classes at American University, McKinley Hall Basement. Information: Guy Brandenburg, 202/635-1860.

Fridays, December 3 and 10, 8:30 PM - Open nights with NCA's Celestron C–14 telescope at Ridge View Observatory; near Alexandria, Virginia; 6007 Ridge View Drive (off Franconia Road between Telegraph Road and Rose Hill Drive). Information: Bob Bolster, 703/960-9126. Call before 6:00 PM.

Saturday, December 4, 5:30 PM - Dinner with the speaker, and NCA members at Costa del Sol, 4906 Fairmont, Bethesda, MD. *See* map and directions on back page.

Saturday, December 4, 7:30 PM - NCA meeting, at Lipsett Auditorium in Building 10 at NIH, will feature Dr. Carol Anne Grady, speaking on "New Views of Photoplanetary Disks" *See* map and directions on back page.

Mondays, December 6, 13, 20, and 27, 7:30 PM - Public nights at U.S. Naval Observatory (USNO), in Northwest Washington, D.C. (off Massachusetts Avenue). Includes orientation on USNO's mission, viewing of operating atomic clocks, and glimpses through the finest optical telescopes in the Washington-Baltimore region. Held regardless of cloud cover. Information: USNO Public Affairs Office, 202/762-1438. Home page: http://www.usno.navy.mil.

See page 6 for more Washington area astronomical events. Other events too numerous to list in *Star Dust* are listed in the publications, *Sky & Telescope*, the *Astronomical Calendar 1999*, the *Observer's Handbook 1999*. NCA members can purchase all these (and much more) at a discount. Information can also be found in numerous software packages, and links available on the NCA Home Page (*see* above for address). To join NCA, use the membership application on page 7.

ACTUATORS, continued from page 1

(1 part in 240 million). This actuator also had to hold its position with the power off and had to operate reliably in the vacuum and thermal conditions of space.

The most critical design parameter for any space-borne device is reliability under adverse conditions. It must work, because there is no way to fix it once it is in space. It is not possible move a ram with such precision and resolution using simple threads, or even differential threads. The basic design chosen by Mr. Vranish was based on getting a speed reduction of 3000:1 in order to drive the output shaft with the needed precision. How do you get a speed reduction of 3000:1?

Our speaker used two differential gears to give speed reduction of 100:1. He saved space by using a 4-way roller bearing as part of the gear set. With a 400:1 moment arm on the threads and a tangent of 3° on the thread size, the combination gives the required total speed reduction of 3000:1. Mr. Vranish also described a flexure nut which allows rotation without static friction. His design has thin radial arms that drag on a central ring. Micro-flexure in the arms puts the system immediately into dynamic friction when movement occurs.

Next, our speaker described the basic electric motor used in the actuator. Mr. Vranish incorporated a Lorenz motor into the design. A Lorentz motor gives somewhat less torque than a conventional pole motor, but it moves without the lumpiness associated with the armature moving from pole to pole. This motor provided 50 pounds of output force at 200 milliamperes of current draw. One of the space-saving features of the Lorenz motor built into the actuator is that the inside of the gear mechanism forms the armature of the motor. Mr. Vranish foresees that some of the design features of this actuator will change the current design features of electromagnetic motors. In future designs, Mr. Vranish is hoping to design actuators that have resolution and precision not just to a millionth of an inch, but to 1/10 of a millionth of an inch.

As soon as a new design model is finished and is working, Mr. Vranish likes to proceed quickly with another way of solving the problem. He described his design approach as being wary of becoming too enamored with your own product. Try some other method, he says; do not get stuck in a single approach. Such a multiple approach spins off many allied devices, some of which may have commercial application. NASA always is pleased when its products for space flight also are useful to advance commercial technology. Mr. Vranish described various

commercial uses which might be made for such actuators as he had designed.

Locking Lorentz Slide

The second actuator device described by Mr. Vranish, involved the use of simple voice coils as actuators, in a device he described as a Locking Lorentz Slide. The design goal was having a voice coil actuator retain its position when off, essentially a latching voice coil. To accomplish this, our speaker designed some new and unique features to a very old device, the sprag (often known as a sprag clutch). A sprag is a device with internal ramps and cylinders, such that the cylinders wedge against the rollers in one direction, but roll freely in the other direction. The result is that when the driving ring is rotated in one direction, it delivers torque to the driven ring, but delivers no torque when rotated in the other direction. A typical device known to all of us that uses this principle is the freewheel on the rear wheel of bicycles. One can describe the sprag as a mechanical diode. Just as a diode passes current in one direction but not in the other, the sprag passes torque in one angular direction but not in the other.

The sprag mechanism depends on friction to pull the rollers into the ramps in order to wedge-in and lock up the driven ring. The NASA space actuators, generally use a molybdenum disulfide grease. This grease has a very low coefficient of friction, but functions well in the conditions of space. Such low friction will cause intermittent operation of the sprag device, since the rollers may continue to spin in the low friction grease, rather than locking into the ramps. Mr. Vranish approached the solution to this problem by redesigning the cylindrical rollers to have angled ramps on each end of the cylinder. This roller then has four points of contact with the ramp, thereby increasing the frictional area. Not only is the frictional area increased, but a stronger frictional force is developed against the angled ends of the roller than is developed in the single-line contact of the plain cylinder. This design of the sprag works well with the moly-sulfide grease, and is relatively efficient. The actuator gives about one-half pound of force when the voice coils are driven at 0.8 tesla of magnetic flux density.

One of the practical uses for the sprag design Mr. Vranish developed was in the design of a ratchet wrench made with two of the sprags. Most ratchet wrenches use a gear and pawl design, whereas the ratchet wrench using the sprag design has a much smoother motion. Dr. Vranish called this new design of the sprag a 3D-sprag. He then coupled the 3D-sprag with a voice coil so as to have two sprags end to end, with voice coils between them, so that the voice coils will stay latched when they are activated in one direction or the other. When the voice coil moves, it opens a sprag and the other voice coil operates the slide, then one voice coil relaxes and the other latches.

One of the potential questions that NASA had about this device, was whether it would unlock reliably. Mr. Vranish said that he struggled with that issue for some time. However, the advantage of using coupled sprags is that only one can take load at a time. If one sprag is locked, the other must be unlocked. The solution to the problem of reliable locking and unlocking, simply becomes an electrical sensor problem.

NCA members asked Mr. Vranish many questions following his presentation. One member pointed out that the sprag mechanism was used in turn-of-the-century automobiles as a parking brake, and the planetary gear system was the basis of the transmission in the Model T. The members were quite fascinated by the use of such ancient mechanical technology in the most modern of today's space borne vehicles to make extremely precise and reliable devices meeting the difficult design standards for NASA. O

Newsletter Deadline for January *Star Dust*, December 15, 1999

Please send submissions to Alisa & Gary Joaquin, at ajglj@erols.com or fax submissions to 703/658-2233. **Text must be in ASCII or Word. Graphics submitted must be in TIFF, GIF, or JPEG.** Thank you.

The Space Shuttle and a Horse's Behind!

by Richard J. Byrd

I cannot vouch for the literal authenticity of this, but it is a great story.

The very first long-distance roads in Europe were built by Imperial Rome for the benefit of their legions. The Imperial Roman chariots were made to be just wide enough to accommodate the back ends of two war horses. The initial ruts in the dirt roads were first made by the wheels of these Roman war chariots. All new equipment had to match the Roman Chariot wheel-spacing, or gauge, else the vehicle would jump all over the road as it wandered in and out of the existing ruts.

Because the first rail lines and rail cars were built by the same people who built the pre-railroad chariots and other horse drawn vehicles, they used the same jigs and tools that they used for building wagons, and hence that same wheel gauge. This gauge became the standard British, and consequently the U.S. standard railroad gauge of 4 feet, 8.5 inches. Hence, the United States standard railroad gauge of 4 feet, 8.5 inches derives from the original specification for an Imperial Roman army war chariot, designed to accomodate the horses.

Now the twist to the story: When you see a Space Shuttle sitting on the launch pad, there are two big booster rockets attached to the sides of the main fuel tank. These are the solid rocket boosters, or SRBs, made by Thiokol in Utah. The engineers who designed the SRBs might have preferred to make them a bit fatter, but the SRBs had to be shipped by train from the factory to the launch site. The railroad line to the factory runs through a tunnel in the mountains. The SRBs had to fit through that tunnel. The tunnel is slightly wider than a railroad track, and the railroad track, as we now know, is just as wide as two horses' behinds. So, a major design parameter of the world's most advanced transportation system was determined by the width of a horse's behind! O

Mid-Atlantic Occultations and Expeditions
Dec. 1999 - early Jan. 2000

by David Dunham

Asteroidal and Planetary Occultations and Appulses

DATE	Day	EST	Star	Mag	Asteroid/ Planetary	dmag	Dur s	Ap. in.	Location
Dec 02	Thu	23:30	SAO 093040	09.2	Saturn		2000	8	all N. America
Dec 16	Thu	19:45	TAC+17d 745	10.5	Nuwa	2.1	18	8	Pennsylvania
Jan 03	Mon	3:11	14 Mon	06.4	Cheruskia	6.0	08	1	Fla. Keys, Bahamas
Jan 10	Mon	1:35	SAO 118158	08.7	Polyxo	4.1	29	2	Savannah, GA
Jan 10	Mon	3:46	ACT18880907	10.4	Emma	2.8	11	6	Brunswick, GA
Jan 16	Sun	20:10	TRC18801817	09.6	Pales	2.2	16	5	Buffalo, NY
Jan 18	Tue	5:07	PPM 128772	10.2	Rachele	1.8	19	6	Hancock, MD

Notes:

Dec. 2: Graze in south polar area. Very difficult.

Jan. 3: Also in Florida later this morning, Vesta will reappear on the dark side of the 9% sunlit waning Moon.

Planned Grazing Occultation Expeditions

DATE	Day	EST	Star	Mag	%	alt	CA	Location
Jan 01	Sat	4:34	SAO 158801	8.0	24-	19	6S	Richmond, VA
Jan 02	Sun	4:35	SAO 159352	8.5	16-	09	6S	Bethesda, Lanham, s. Bowie, MD
Jan 02	Sun	5:10	gamma Lib	3.9	16-	19	8S	Matecumba Key, FL
Jan 09	Sun	17:45	delta Cap	2.9	09+	20	5S	Mercersburg & Scranton, PA
Jan 12	Wed	21:58	ZC 0044	7.4	34+	10	2S	Fairfax, VA; DC; Annapolis, MD

Notes:

Jan. 2, gamma Librae: This is a good camcorder/binoculars occultation in the eastern third of the USA, with a spectacular graze in the Florida Keys. I plan to try to observe it, along with the occultation of 6th-mag. 14 Monocerotis by the asteroid Cheruskia on the morning of the 3rd; *see* above. If you might be interested in these events, let me know.

Jan. 9, 2000: This is the best graze in the region during 2000; it should be easy to observe with binoculars or directly with 12x or higher camcorders. *See* http://www.lunar-occultations.com/iota, and the next *Star Dust*, for our expedition plans to Mercersburg, 15 miles n.w. of Hagerstown, MD.

Total Lunar Occultations

DATE	Day	EST	Star	Mag	%	alt °	CA	Notes
Dec 09	Thu	18:06	D ZC 2704	5.9	03+	2	61N	Low in s.e., az. 240 deg.
Dec 12	Sun	12:16	D Mars	0.9	19+	15	33N	Duration 33s; Sun alt. 28

Dec 12	Sun	12:54	R Mars	0.9	20+	20	-18N	Duration 36s; Sun alt. 27
Dec 17	Fri	20:27	D ZC 0208	7.0	71+	53	73S	
Dec 17	Fri	22:05	D ZC 0210	6.6	71+	43	20N	
Dec 20	Mon	23:28	D 63 Tauri	5.6	96+	65	75S	
Dec 25	Sat	1:45	R delta Cnc	3.9	90-	66	78S	
Dec 25	Sat	4:53	R ZC 1321	6.7	90-	55	45N	Double, 0.2", PA 234 deg.
Dec 28	Tue	4:37	R ZC 1684	6.8	62-	56	41S	
Dec 28	Tue	5:07	R SAO 118952	7.1	62-	57	80N	
Dec 30	Thu	4:59	R SW Vir	7.1	41-	41	75N	= SAO 139236, Sp. M7 (red)
Dec 31	Fri	3:47	R ZC 2005	7.0	32-	21	81N	
Jan 01	Sat	4:49	R SAO 158801	8.0	23-	21	31s	Graze in Richmond, VA
Jan 02	Sun	4:40	D gamma Lib	3.9	16-	10	-76S	Moon Az. 118 deg.
Jan 02	Sun	5:52	R gamma Lib	3.9	15-	21	90S	12x camcorders; Graze in FL

Five Lunar Impacts Confirmed

by Alisa and Gary Joaquin, eds.

On November 18, Pedro Valdes Sada of the University of Monterrey in Mexico, Brian Cudnik, a research assistant at Texas A&M, and David Palmer of Goddard Space Flight Center, each observed lunar meteor impacts that were confirmed by our own David Dunham. Below are excerpts from David's personal summary found on his web site at http://iota.jhuapl.edu:

"Brian Cudnik in Houston, Texas, was watching the dark side of the Moon late Wednesday night with a 14-inch telescope and saw a brief bright flash at "about 10:46:20 pm CST" near the center of the dark side, a short distance in from its edge. At the same time, I was videorecording the dark side of the Moon using a 5-inch telescope at Mount Airy, Maryland. Sure enough, when I played back the tape, the event is there in the location described, at 11:46:15 pm EST (= 10:46:15 pm CST = 4:46:15 of Nov 18 UT). The meteor was probably a Leonid, since the main part of the Leonid meteor stream struck the Earth at 9 pm EST, and with the Moon trailing the Earth, the Moon would have crossed the thick part of the stream 2-3 hours later.

Pedro Valdes Sada reported two lunar flashes that he videorecorded near Monterrey, Mexico, about half an hour after the event seen by Brian Cudnik and recorded by me... They are also on my tape at the times he gives!... The new objects are also probably Leonids, since it was still near the time the peak was striking the Moon, but of course we do not know for sure, since we don't know from which direction the meteoroids approached the Moon.

For observers, a key to my success in this endeavor was the focal reducing lens that I purchased from Orion; it decreased the f-ratio of my 5-inch Schmidt-Cassegrain telescope from 10 to 6.3. That not only increases the field of view by more than a factor of 3 in

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Yet Another Y2K Problem

by Leith Holloway

The year 2000 is the first centennial year in 400 years to be a leap year. Years 1700, 1800 and 1900 were common years. This may cause trouble for calendar makers who are not aware of a subtle rule in the Gregorian calendar.

The Julian calendar had an intercalary day inserted at the end of February in every year exactly divisible by four. This made the Julian calendar about eleven minutes longer than the tropical year on which our calendar is based and caused the March equinox to drift slowly toward the beginning of this month.

In 1582 Pope Gregory XIII stopped this drift by subtracting ten days from the calendar in October of that year and by decreeing that in the future, three centennial years out of four will be common years. Only centennial years that are exactly divisible by 400 would be leap years.

Therefore, the Gregorian calendar requires that the year 2000 be a leap year and not a common year as the three previous centennial years were. Most calendar makers understand this and will print correct calendars. Murphy's Law, however, has not been repealed, and it is possible that a few calendar makers will produce inaccurate year 2000 calendars. Be wary and check all of your year 2000 calendars for this error.

Year 2000 calendars should have a Tuesday, February 29 followed by Wednesday, March 1. Prompt discovery of this error should enable you to get a refund or a replacement from the merchant. You may wish to keep the incorrect calendar as a collector's item. It may someday turn out to be more valuable than the price you paid for it. ○

Don't throw this newsletter away. If you're finished with it, pass it on to someone else to read or recycle it. It's right for astronomy and the environment.

National Capital Area Astronomical Events

Free Lectures at the Einstein Planetarium and Other Daily Events
National Air & Space Museum

202/357-1550, 202/357-1686, or 202/357-1505 (TTY)
Home page: http://www.nasm.edu

Other Area Astronomical Events

Goddard Scientific Colloquium — All seminars will be held in Building 3 Auditorium at 3:30 PM.

"Life in the Universe: Is Life Digital or Analog?," speaker, Freeman Dyson, Institute of Advanced Study, Dec. 3.

"Hypernovae and Gamma Ray Bursts," speaker, Bohdan Paczyski, Princeton University, Dec. 10.

Laboratory for Astronomy and Solar Physics — All seminars are on Thursday at 3:00 PM in Building 21, Room 183A.

"Measuring Large Scale Structure with the Sloan Digital Sky Survey," speaker, Alex Szalay, Johns Hopkins University, Dec. 2.

"Mystery Spot in Supernova 1987A as Gamma-ray Burst," speaker, Jim Felten, GSFC, Dec. 9

"ST-2010," speaker, Jon Morse, University of Colorado, Dec. 16.

Maryland Space Grant Observatory — Open House every Friday evening (weather permitting), Bloomberg Center of Physics and Astronomy, Johns Hopkins University, Baltimore, MD. Information: 401/516-6525 or check their web site at www.pha.jhu.edu/facilities/observatory/telescope.html.

Montgomery College's Planetarium, Takoma Park — "The Day of the Sun's Return, the Winter Solstice" Dec. 22, 7:00 PM.

National Academy's Science Lecture Series — All lectures to be given on a monthly basis in the Auditorium of the National Academy of Sciences (2101 Constitution Ave., NW, Washington, DC). All lectures will begin at 5 PM. Nerest Metro station is Foggy Bottom on the Orange and Blue lines.

"Rediscovering the Red Planet: Latest Results from the Exploration of Mars," speaker, Maria Zuber, Massachusetts Institute of Technology, Dec. 10.

University of Maryland College Park Astronomy Department Colloquia — All colloquia are held on Wednesdays at 4:00 PM. Location will vary.

"Gamma-Ray Bursts as a Probe of the Very High-Redshift Universe," speaker, Dr. Donald Lamb, University of Chicago, Dec. 1. Location: CSS 2400.

Meteor Showers

Full Moon

December 22

Major Activity

Radiant	Duration	Maximum
Geminids	Dec. 6-19	Dec. 14 10:49 UT

Minor Activity

Delta Arietids	Dec. 8-Jan 2, 2000	Dec. 8/9
11 Canis Minorids	Dec. 4-15	Dec. 10/11
Coma Berenicids	Dec. 8-Jan 23, 2000	Dec. 18-Jan. 6, 2000
Sygma Hydrids	Dec. 4-15	Dec. 11/12
December Monocerotids	Nov. 9-Dec. 18	Dec. 11/12
Northern Chi Orionids	Nov. 16-Dec. 16	Dec. 10/11
Southern Chi Orionids	Dec. 2-18	Dec. 10/11
Phoenicids	Nov. 29-Dec. 9	Dec. 5/6
Alpha Puppids	Nov. 17-Dec. 9	Dec. 2-5

Daylight Activity

None

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area, but also increased sensitivity by concentrating the seeing disk of point sources onto fewer pixels, and allowed, for example, recording (faintly) the Earthlit dark side of the Moon...

David Palmer reported two more lunar impacts that he videorecorded at his home in Greenbelt, Maryland at 3:49:41 and 4:08:00 UT of 1999 November 18. The times are estimated to be accurate to +/-3 seconds since they were obtained just by calibrating the VCR clock with time from the CNN cable TV broadcast. The flashes are also in the video recording that I made at Mount Airy, about 60 km to the northwest, bringing the total now to five confirmed lunar impacts, four of them on my tape and also on other videotapes made by others, and the other, the first one reported, confirmed with Brian Cudnik's timed visual observation...

Several have asked me how large the impacting meteors are, and if the new crater they form might be seen. I need help from an expert in impact dynamics on this - I don't have expertise in that field. I have heard one estimate that the impactors, to produce flashes this bright, are meter-size, but another estimate is that they may be just 100 grams or so. In any case, I believe that the "splash" that these objects made are less than 100m across and will not be visible with Earth-based telescopes. In 2003, the Japanese Selene spacecraft plans to map the Moon from low orbit in detail, and comparison of its images with those of Lunar Orbiter, Apollo, and/or Clementine will hopefully reveal some small new craters." ○

National Capital Astronomers, Inc.

SERVING SCIENCE & SOCIETY SINCE 1937

NCA is a non-profit, membership supported, volunteer run, public-service corporation dedicated to advancing space technology, astronomy, and related sciences through information, participation, and inspiration, via research, lectures, presentations, publications, expeditions, tours, public interpretation, and education. NCA is the astronomy affiliate of the Washington Academy of Sciences. All are welcome to join NCA.

SERVICES & ACTIVITIES:

Monthly Meetings feature presentations of current work by researchers at the horizons of their fields. All are welcome; there is no charge. *See* monthly *Star Dust* for time and location.

NCA Volunteers serve as skilled observers frequently deploying to many parts of the National Capital region, and beyond, on campaigns and expeditions collecting vital scientific data for astronomy and related sciences. They also serve locally by assisting with scientific conferences, judging science fairs, and interpreting astronomy and related subjects during public programs.

Discussion Groups exchange information, ideas, and questions on preselected topics, moderated by an NCA 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.

NCA Information Service answers a wide variety of inquiries about space technology, astronomy, and related subjects from the public, the media, and other organizations.

Consumer Clinics on selection, use, and care of binoculars and telescopes, provide myth-breaking information, guidance, and demonstrations for those contemplating acquiring their first astronomical instrument.

Dark-Sky Protection Efforts educate society at large about the serious environmental threat of light pollution, plus seek ways and means of light pollution avoidance and abatement. NCA is an organizational member of the International Dark-Sky Association (IDA), and the National Capital region's IDA representative.

Classes teach about subjects ranging from basic astronomy to hand-making a fine astronomical telescope. NCA's instructors also train educators in how to better teach astronomy and related subjects.

Tours travel to dark-sky sites, observatories, laboratories, museums, and other points of interest around the National Capital region, the Nation, and the World.

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

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

NCA Juniors Program fosters children's and young adults' interest in space technology, astronomy, and related sciences through discounted memberships, mentorship from dedicated members, and NCA's annual Science Fair Awards.

Fine Quality Telescopes up to 36-cm (14-inch) aperture are available free for member's use. NCA also has access to several relatively dark-sky sites in Maryland, Virginia, and West Virginia.

YES! I'D LIKE TO JOIN THE NATIONAL CAPITAL ASTRONOMERS

Enclosed is my payment for the following membership category:

[ ] Regular
- [ ] *Sky & Telescope* and *Star Dust.* ($57 per year)
- [ ] Star Dust only ($27 per year)

[ ] Junior (Only open to those under age 18) Date of birth: _____
- [ ] *Sky & Telescope* and *Star Dust.* ($45 per year)
- [ ] Star Dust only ($15 per year)

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Street or Box Apartment City State Zip Code + 4

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 $27 when it expires.

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

NCA c/o Jeffrey B. Norman, 5410 Connecticut Avenue, NW, Apt. #717, Washington, D.C. 20015-2837.

The following information is optional. Please indicate briefly any special interests, skills, education, experience, or other resources which you might contribute to NCA. **Thank you, and welcome to NCA!**

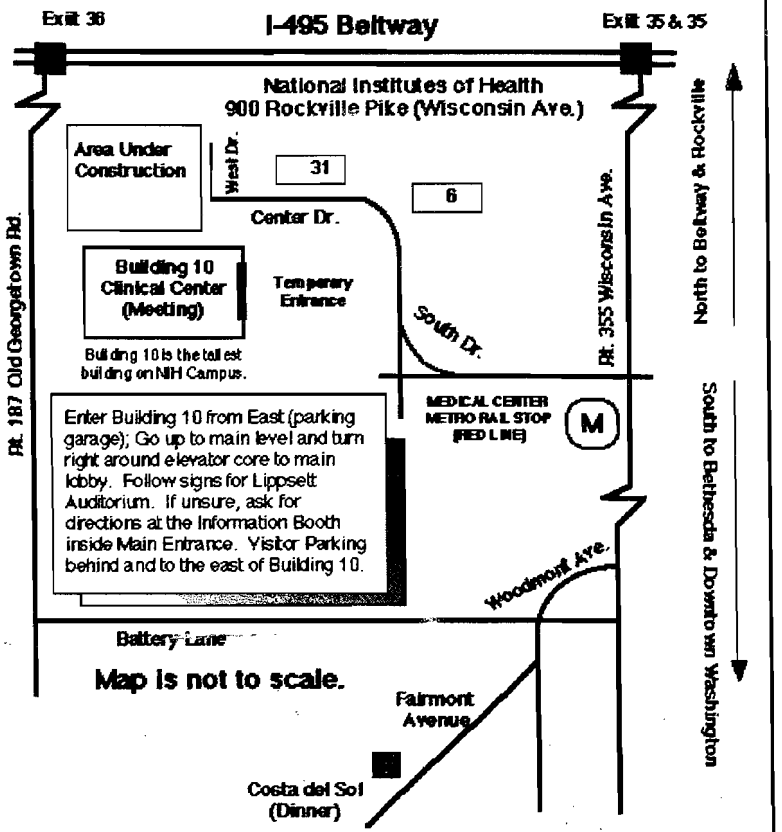
_____

_____

Getting to the NCA Monthly Meeting

Metrorail Riders - From Medical Center Metro Station: Walk down the hill, pass the bus stops and turn right at the anchor onto Center Drive. Continue uphill to Building 10, the tallest building on campus (walking time about 10 minutes). 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 Costa del Sol - Take Wisconsin Avenue toward Bethesda and bear right onto Woodmont (or take right onto Battery Lane and left on Woodmont). Follow Woodmont to Farirmont and make a right. The restaurant is a few blocks down (4906 Fairmont Avenue). There is parking around the corner on a side street. Seats are not guaranteed after 5:30.



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4620 N. Park Ave., #306W
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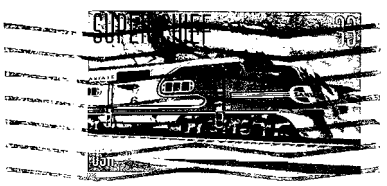

FIRST CLASS

DATED MATERIAL

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3/31/00