Star Dust

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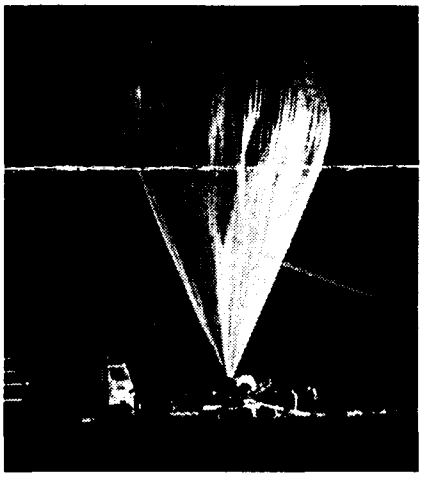
Carol Jo Crannell to Speak on "Imaging Solar Flares in Hard X-Rays and Gamma Rays from Balloon-Borne Platforms"

by Harold Williams

The next meeting of the National Capital Astronomers will be held on Saturday February 4 at 7:30P.M., in the Bunim room on the ninth floor of the Clinical Center (building 10) at the National Institutes of Health (NIH). Carol Jo Crannell of the Goddard Space Flight Center and the Catholic University of America will speak on "Imaging Solar Flares in Hard X-Rays and Gamma Rays from Balloon-Borne Platforms." The speaker sent the following abstract: "Imaging solar flares in hard x-rays and gamma rays is the current scientific frontier for solar flare physics. In the United States, development of the capability began with the High Energy Imaging Device (HEIDI) Balloon Project. With HEIDI, we implemented a Fourier-transform imaging technique using rotating modulation collimators (RMCs). As configured for its first flight, the HEIDI payload had two RMCs with 25-arcsecond and 11-arcsecond angular resolution, respectively; sensitivity to photon energies as high as 700 keV; and time resolution for individual photon events of 100 microseconds. It flew on June 22, 1993, and was pointed at the Crab Nebula and at the Sun throughout the six-hour flight. Visual demonstrations of how the technique works, development of the payload, and photographs of Balloon-flight preparations will be presented."

Solar flares are some of the most energetic events that occur in the Sun's atmosphere. Flares happen low in the Sun's atmosphere near active regions with frequent occurrence timed with the solar activity cycle, roughly every 11 years. Flares are thought to be a result of magnetic instabilities, but they are much more violent (and even less well understood) than prominences. In prominences the surface of the sun appears to lash out in tongues of flame, quite often arcing back to the surface. Most prominences are probably loops, but loop prominences are seen only if viewed from the correct angle. The larger prominences can release up to 10^{32} ergs of energy over days or weeks, which while large by terrestrial standards, is not much compared with a total solar luminosity of 4×10^{33} erg/s. Solar flares, though, release 10^{32} ergs of energy in a matter of minutes or hours, equaling the largest prominences in total energy. The flares' temperatures are also much more extreme and can reach 10^8 K. Even the temperature in the interior of the sun is only a few times 10^7 K. Unlike the loop prominences, where most of the particles fall back into the sun, the flares simply blast the material into space. These more energetic events require imaging at higher frequencies than the visible because at the temperatures and energy densities of flares all the real action is occurring in x-rays and gamma rays.

X-rays and gamma rays are fortunately absorbed by the earth's atmosphere, so humans are safe from this highly ionizing radiation, but to see what is going on in x-rays and gamma rays these observations must be made above the earths' atmosphere. It is much cheaper to get above the earth's atmosphere by Balloon than by satellite. It would be prohibitively expensive to do this from orbit, to test and prototype new instruments. Once good instrument are developed in these wave bands with the angular resolution needed to do good science, then it will make sense to put the instrument in orbit. HEIDI is preparing the way for HESP, the High Energy Solar Physics satellite mission. Should HESP not be funded, then HEIDI can do some of the science with Balloon flights during the next solar maximum near the year 2000.



The balloon used to carry the HEIDI payload as it was being filled prior to flight. Photograph taken by John Herbold.

The angular resolutions of HEIDI of 11 and 25 arcseconds corresponds to spatial resolutions of 8 and 18 thousand kilometers' resolution on the surface of the sun—the earth is 13 thousand kilometers across.

Calendar of Monthly Events

The Public is Welcome!

Wednesday, February 1-February "Sky Watch" column by Blaine P. Friedlander, Jr. appears in *The Washington Post* "Style" section. It lists many other events for the month.

Fridays, February 3, 10, 17, and 24, 8:30 PM-Open nights with NCA's Celestron 14-inch telescope at Ridgeview Observatory; near Alexandria, Virginia, 6007 Ridgeview Drive (off Franconia Road between Telegraph Road and Rose Hill Drive). Information: Bob Bolster, 703/960-9126.

Fridays, February 3, 10, 17, and 24, 7:30 PM-Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

Saturday, February 4, 5:30 PM-Dinner with the speaker at the La Panetteria Restaurant, 4921 Cordell Avenue Ave., Bethesda, MD., before the monthly meeting. Reservations are for 5:30 p.m., sharp. Refer to map and description on back page.

Saturday, February 4, 7:30 PM-February NCA meeting will feature Carol Jo Crannell (Goddard Space Flight Center) speaking about "Imaging Solar Flares from Hard X-Rays and Gamma Rays from Balloon-Born Platforms."

Saturday February 4, Night (After The Meeting)-Waxing crescent Moon provides this month's Saturday night with *second longest* deep night period (i.e., continuous time interval with nether daylight, twilight, or moonlight), although period doesn't begin until Moon sets. *See* February 25th listing. Information: Daniel Costanzo, 703/841-4765.

Mondays, February 6, 13, 20, and 27, 8:30 PM-Public nights at U.S. Naval Observatory (USNO), in Northwest Washington, DC (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. Information: USNO Public Affairs Office, 202/653-1541.

Tuesdays, February 7, 14, 21, and 28, 7:30 PM-Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

Saturday, February 25, Night-Waning crescent Moon provides this month's Staurday night with *longest* deep night period and February's only Saturday night when Moon entirely out of sky between dusk and Midnight EST. Several relatively dark-sky sites are available for NCA member's use. Information: Dan Costanzo, 703/841-4765.

Tuesday, February 28, 6:30 PM-Carnegie Institution of Washington Capital Science Lectures (Free to the public), Roald Sagdeev, distinguished Professor and Director of East-West Space Center, Department of Physics, University of Maryland at College Park, MD speaking on "Chaos in Real Systems: The Limits of Predictability and Control". *Can "chaos theory" help predict and control the behavior of complex systems?* Information: Ms. Sherrill Berger, 202/328-6988

Tuesday, February 28, 7:30 - 9:30 PM-Celestial Navigation Course, a six week program (12 classes) in celestial navigation fundamentals, including use of sextant and the hand calculator will be offered in Bethesda, MD. The instructor, NCA member, George Lear, is a USCG licensed master with offshore sailing experience as coash with the USNA Sailing Squadran, a professional engineer, and former college math instructor. Information: George Lear, 301/986-0314.

Wednesday, March 1-March "Sky Watch" column by Blaine P. Friedlander, Jr. appears in *The Washington Post* "Style" section. It lists many other events for the month.

Saturday, March 4, 7:30 PM-March NCA meeting will feature David Batchelor (Goddard Space Flight Center) speaking about "Observing The Sun From Earth And Space."

Other events too numerous to mention here are listed in *Sky & Telescope*, the *Astronomical Calendar 1995*, the *Observer's Handbook 1995*, and in numerous software packages. NCA members can purchase all these at a discount. To join NCA, use membership application on page 7.

The Formation of Binary Stars through Fission of a Single Mass: Past and Present

Reviewed by Harold William

On January 7, 1995 at the National Institutes of Health (NIH), Dimitris Christodoulou of Louisiana State University spoke to us on "The Formation of Binary Stars through Fission of a Single Mass: Past and Present."

The route to the formation of binary stars through fission of a single mass by a process that is analogous to a phase transition is a fairly new idea. Some of this material has only just been published or accepted for publication. The research is ongoing, and Dimitris wishes to speak to us in a year or so from now to tell us what has developed since then. The content of this talk would be new even to researchers on binary stars, unless they were collaborators with Dimitris or referees of the scientific papers.

Most stars are binaries. A conservative estimate of the number of stars that are binary is 70%, and the true number may be nearly 100%. There must be a generic, simple mechanism for forming binary stars. All other mechanisms, of which there are many, form binary stars in restricted contexts; no doubt some of these mechanisms produce binary stars, but the community has never been satisfied that these other mechanisms could produce binary stars in the requisite numbers. Thus binary star formation from a single mass has remained one of the Holy Grails of star formation.

What kinds of shape can objects assume to represent binary stars? If these shapes are equilibrium shapes—those for which the forces are in balance— then we know that nature will find a way to produce them naturally. Changing only a parameter or can produce two different equilibrium sequences. Varying one parameter, the flattening for instance, produces sequence of equilibria. These sequences of equilibria, produced by variation of this one parameter, can then name or classify the sequence. Varying different parameters will produce families of equilibria.

The names of the different equilibrium sequences honor the people who first found them and bear such names as Maclaurin, Jacobi, Dedekind, and Riemann, all great and famous eighteenth and nineteenth century mathematicians. The simplest and first sequences discovered were the Maclaurin spheroids (1742). These objects are axisymmetric, and only the flattening varied as the rotational speed increased. Jacobi (1834) realized that the equilibria did not have to be axisymmetric and could become triaxial with three unequal axis—true ellipsoids. Riemann introduced a third parameter, uniform vorticity, but any viscosity tends to reduce vorticity to zero. Vorticity is motion in the fluid after one has taken out the rotation of the fluid as a whole. (Another way of viewing vorticity is as internal circulation after one has moved to a rotating frame so as to remove the uniform rotation motion.) The Jacobi sequence is a special Riemann sequence with vorticity equal to zero.

Poincare (1885) put the work of Maclaurin and Jacobi and others together, showing the relationship and bifurcation between the sequences. A bifurcation would be when one sequence joins another in a parameter space such as flattening. In bifurcation the mother sequence branches off to form a daughter sequence. Sometimes there will be different sequences, all with the same conserved quantities. A general principle of physics is that systems naturally seek the lowest energy state that is consistent with the relevant conservation laws. When a series of equilibria are displayed, the one with the lowest energy is the one that nature will try to go toward. The pear-shaped sequence—that is, really an egg-shaped sequence (Poincare had no 3-D modeling software)—when it bifurcates from the Jacobi sequence turns and twists back on itself in phase space. This egg-shaped sequence followed by Poincare, Cartan, and Jeans is a higher energy state, not a lower energy state, and this result sent the scientific field down the wrong path into a dead end.

With the invention of computers many equilibrium sequences can now be calculated that could not be calculated analytically, with shapes whose forms can be described as "concave hamburgers," "donuts," and "dumbbells." The transition between equilibria to the lower energy states can occur as a type of phase transition. The type of phase transition is not like the gas, liquid, and solid phase transition, but like the lambda transition in liquid helium four near 2.2 K that leads to superfluidity with an infinite specific heat and many other weird properties.

This talk is the most difficult that I have ever reviewed because of the importance of diagrams that I cannot reproduce in *Star Dust*. There were many questions asked during and after the talk. One of the more important questions was how quickly things change from a Jacobi, triaxial ellipsoid, to a "dumbell." The answer was that the system is driven by a viscous timescale in the models addressed so far, but in other cases, in parameter spaces where there are dynamic instabilities, the change is driven by the free-fall time scale, a rotation or two of the star-forming cloud. These changes in state should occur fairly rapidly compared with the time that a star spends on the main sequence. Dan Costanzo has ask me to explain in this review what is meant by astrophysical fluid. A fluid is a liquid or a gas. Real stellar systems are, of course, not incompressible liquids (water is approximately an incompressible liquid), but compressible gases of nonuniform density. In the original work done by Maclaurin, Jacobi, Dedekind, Riemann, and Poincare they assumed that a star was an incompressible fluid (liquid) for mathematical convenience. Had they not made this assumption, they would not have been able to do any analytic calculations at all. They realized that a real star must be a compressible gas, but they did not have computers and could not handle this complication. It has been suspected that these idealized incompressible fluid sequences are in some ways similar to the more complicated gas dynamic cases. This has indeed been shown to be the case with the evolution of the Maclaurin spheroids and their gaseous counterparts with the specific angular momentum distributed like a Maclaurin spheroid. It has even been shown that varying compressibility does not even make a qualitative difference. It's all in the topology and the interchange of the variables that produce the topology, the shape of the equilibria.

As usual, we are indebted to NIH and NCA member Jay Miller for arranging to meet at NIH, where he works.

Newsletter Deadline for

March *Star Dust*

February 15, 1995

Send Submissions to Gary & Alisa Joaquin, at 7821 Winona Ct., Annandale, VA, 22003, or send an ASCII file via E-Mail at 71561.1747 @compuserve.com or fax to 703/658-2233. Submissions must be on time or they may not get in. Wishing everyone a Happy Valentines Day.

Dark Matter on Public Radio

By Gary L. Joaquin and Daniel J. Costanzo

Quality, informative, and educational radio programs featuring space technology, astronomy, and related sciences are presented at irregular intervals on public radio, WAMU, 88.5 FM. The following is a summary of an hour of the *Diane Rehm Show* broadcast on January 3rd, "The Current Debate Over Dark Matter". Diane's guests that day were Dr. John N. Bahcall of the School of Natural Sciences at the Institute for Advanced Studies in Princeton, Dr. Richard Berendzen, of the Department of Physics at American University, Dr. Francesco Paresce of the European Space Agency and the Space Telescope Science Institute, and Dr. Vera C. Rubin, an astronomer with the Department of Terrestrial Magnetism at the Carnegie Institution in Washington.

Somewhere between ninety and possibly even as much as ninety nine percent of all matter is "missing". This missing matter is also known as "dark matter", so named because it emits no detectable radiation of any kind. We can infer that this matter exists only by its gravitational influence upon matter that we can detect. Galaxies gravitationally hold themselves much better than they should given the amount of matter that we can detect. Also, the stars within galaxies, even our own Milky way, are travelling much faster than they should. It is as if there is an unseen hand guiding these bodies.

The amount of matter in the universe has concerned astronomers and cosmologists ever since Edwin Hubble discovered in the 1920s that galaxies are rushing away from each other at tremendous velocities, arguably the greatest scientific discovery of the 20th century. The density of matter actually determines the fate of the universe. We have reasoned that a cataclysmic explosion known as the "Big Bang" sent all of this matter hurtling off into oblivion. If the density of the universe is great enough, then after the universe expands to a certain size, it will begin to contract, compressing itself into a densely packed mass. This scenario is known as "The Big Crunch". At the other end of the spectrum is a universe with insufficient mass to halt the rate of expansion. Without enough mass the universe will continue to expand and cool, exhausting all of its energy. This scenario is called "The Big Chill". Our current knowledge suggests that we do indeed live in a very low density universe where too little matter exists to halt the rate of its expansion.

Several explanations have been posed to account for this missing mass. Dark matter could possibly be in the form of nonluminous or underluminous objects, like smaller cooler stars know as red dwarfs. Up until recently, it was thought that many of these stars could be found, if we only had sensitive enough equipment to detect them. Dr. Bahcall reported that recent surveys completed with the Hubble Space Telescope simply did not reveal the colossal number of these objects required to account for the missing mass. Stars of 1/10 of a solar mass and less, apparently do not form in such large numbers in Nature. Matter trapped in black holes has also been offered in explanation, but once again observation does not confirm this hypothesis.

Since explanations have not been forthcoming using normal baryonic matter, astronomers and physicists have been forced to reexamine their theories. Dr. Paresce offered that perhaps we don't understand our Newtonian physics on a galactic level. Currently, disputes are not confined to the topic of dark matter. Even at this moment a debate rages in scientific circles over how to resolve the discrepency of stars that appear to be older than the universe itself.

Dr. Rubin, an expert on galactic dynamics pioneered early work identifying dark matter over two decades ago, confessed, "Maybe our listeners think we know more than we do. Much of our work in cosmology is based upon very few observations. When I first started studying observational cosmology, it meant one number; how fast is the universe expanding? Now it has grown to 100 times that. We know more. When we talk about the earliest universe or the future universe millions or bil-

See DARK MATTER, on Page 5

Montgomery College's Public Planetarium

Exciting public planetarium programs are offered at Takoma Park's own planetarium. Astronomy is one of the few sciences accessible to any inquiring mind. All programs begin at 7:00 p.m. There is no admission charge.

Saturday, February 25, 1995

"African Skies"

The planetarium is attached to the Science South building on the ground level and has a conspicuous silver-colored domed roof.
Montgomery College Planetarium
Montgomery College, Takoma Avenue and Fenton Street
Takoma Park, MD 20912-4197. Phone: 301/650-1463

DARK MATTER, from Page 4

lions of years from now we don't know very much. Even theory waits for new observations" .

We are indeed limited by our observations and especially by our observational instruments. Dark matter may exist in the form of nonbaryonic matter, in a great number of undiscovered exotic subatomic particles. Perhaps we need a new kind of telescope, a detection device that does not require electromechanical radiation to work.

Diane Rehm challenged her guests to explain why finding missing matter mattered at all in everyday life. Dr. Rubin shared that there is an innate curiosity in each of us to find out what makes the Universe work. Ever since she looked up at the stars as a child she could not conceive of devoting her life to any other type of work. She also expressed disappointment that almost no women had called in with questions on this radio broadcast and that relatively few women were involved in science. We need to encourage more women, especially more young girls that science is for them, too.

Dr. Bahcall made a very poignant observation. "In the previous century and going up into the late 1930s ... we were trying to answer the question of how the sun shines, and in general how stars shine. There wasn't an adequate answer to that early on.... It was later provided as nuclear physicists and Einstein provided special information about special relativity. It was possible to work out theoretically and physically how nuclei burned in the center of sun. We now think that is an adequate theory and it had of course tremendous implications for human beings that were unanticipated... It lead to the horror of nuclear bombs but it also leads to the enormous promise in the next century of almost unlimited energy sources... If you had asked someone at the end of the nineteenth century, 'Would the theoretical speculations of physicists and astronomers about how the stars shine ever be of practical use?', they would have said, 'Certainly not. Don't be ridiculous. That is very esoteric. It has nothing to do with our everyday existence'."

Moments later a caller made a comment about astronaut Edgar Mitchell's Apollo 14 lunar mission that resonated with Dr. Bahcall's observation. During his return flight Mitchell related experiencing a profound feeling of being at home in a universe that felt like a benign living organism. Dr. Berendzen responded, "This idea is not new. It goes back as far as the Pythagoreans of ancient Greece who thought the same thing. Many of the astronauts have experienced a profound philosophical and even theological experience. Seeing our planet as one globe is a powerful experience. From that perspective, you no longer see geopolitical theory. You see one delicate shared planet." This unexpected byproduct of our science and technology may provide the unity required to preserve our ecosystem and our species.

Diane Rhem posed the closing question "Where is the next frontier of science going to be with regard to defining dark matter?" Dr. Rubin was not daunted by the elusiveness of dark matter. She noted that in the history of science when we run into a dead end it is wise to take another path. The solutions that we seek often comes from the most unexpected directions, implying a connectedness that is not always apparent. Dr. Bahcall's final comment is a study in humility and perseverance: "We do what we always do in science, Diane. We do what a drunk man does when he loses his keys at night. We look for it under the lamp post that is lighted and keep looking hoping that there is where the keys are. We have no other choice. It may be that we will find our keys quickly because we happen to have the tools or it may be that our keys lie nearby but in the dark. We'll just have to wait for some technological breakthrough."

Science and Technology Public Radio Programs

Quality, informative, and educational radio programs featuring space technology, astronomy, and related sciences (like the above article on dark matter) are presented at irregular intervals on WAMU-FM at 88.5 MHz. For program listings, call **WAMU** Public Radio Listener Talk Show Hotline: 202/885-1200 & Press 3.

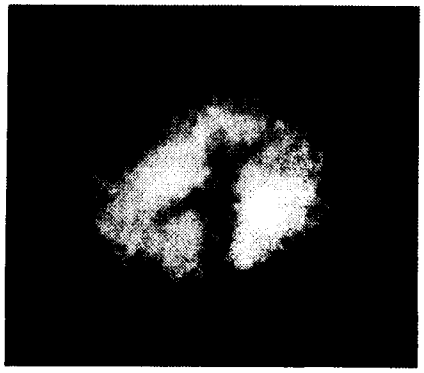
Theorists Make a Bid to Eliminate Black Holes

Science, 23 December 1994, page 1945

An Abtract by John B. Lohman

Most physicists believe that black holes — objects so dense that even light cannot escape them — exist. They are a consequence of Einstein's General Theory of Relativity. Some theorists are uneasy about them because they contain singularities; points of infinite density and gravitation.

Two groups of theorists (one group from the University of Toronto and the second from the University of Maryland) have constructed modifications of Einstein's theory that eliminate black holes, but agree with the astrophysical evidence for black holes. Most theorists doubt them, but take them seriously. Even if these attempts do not hold up, they certainly won't be the last.



This image of the core of nearby galaxy M51, taken by the Hubble Space Telescope's Wide Field Planetary Camera, shows a striking, dark "X" across the galaxy's nucleus. The "X" is due to absorbtion by dust and marks the exact position of a black hole. The darker bar may be an edge-on dust ring 100 light years in diameter. It determines the axis of a jet of high-speed plasma and confines radiation from the accretion disk to a pair of oppositely directed cones of light. Credit: H. Ford (JHU/STScI), the FOS IDT, and NASA.

Still Available

The Observer's Handbook 1995

See Jeff Norman at the Monthly Meeting

Only a few copies are left.

Important Information Numbers

Smithsonian Sky Watchers' Report: Non-technical information recording on astronomical events, objects, and phenomena in the Washington, D.C. region's sky. Updated weekly. 202/357-2000

***Sky & Telescope* "Skyline"**: Moderately technical information recording on latest in space technology, astronomy, and related sciences. Updated weekly, or sooner if necessary. 617/497-4168

McDonald Observatory "Star Date": Non-technical information on space technology, astronomy, and related subjects. Broadcast weeknights, around 8:00 PM, by listener-supported public radio station WAMU FM 88.5

AccurateTime Services (via phone line): Eastern Time (in 24 hour mode) and Universal Time given via the U.S. Naval Observatory and the National Institute of Standards and Technology. Excellent for synchronizing clocks and watches. (Voice Recordings) 202/653-1800, 900/410-TIME, and 303/499-7111; (Modem Time Service) 202/653-0351

"Space Weather" Indices: Highly technical, but quite useful recording on Solar activity and its effect on Planet Earth. From the National Oceanic and Atmospheric Administration. Updated every three hours. 303/497-3235 (anytime) or WWV at 2.5, 5, 10, 15, and 20 MHz (at 18 minutes after every hour)

Local Weather, Weather, Sunrise/Sunset, & UV Index: Recording of latest weather forecast out to five days, plus Sunrise/Sunset times, and forecasted Solar ultraviolet radiation index. Covers Washington, DC and vicinity. 703/260-0307

NCA Artificial Satellite Prediction Service: Free customized prediction of viewing opportunities. Satellites frequently are clearly visible to unaided eyes or binoculars, even from light polluted areas. Contact Walter I. Nissen, Jr., (voice phone) 216/243-4980, (e-mail) dk058@cleveland.freenet.edu

NCA Jupiter Galilean Moon Prediction Service: Free customized prediction of viewing opportunities for Jupiter's four Galilean moons. They are clearly visible in small telescopes and binoculars, even from heavily light-polluted areas. Contact John Lohman (voicephone) 703/820-4194 at least one week prior to anticipated viewing.

Occultation Line: Highly technical, but useful voice recording with latest updates on occultations and grazings of stars by the Moon, planets, and asteroids; from the International Occultation Timing Association. Many of these events are visible with the unaided eye, binoculars, and small telescopes. 301/474-4945

Other Free Public Science & Technology Lectures: National Air and Space Museum (NASM): 202/357-1552 (ask to receive NASM bimonthly calendar by mail); University of Maryland (Astronomy Department): 301/405-3001; Goddard Space Flight Center (Goddard Visitor Center): 301/286-8981; Carnegie Institution of Washington: 202/328-6988 or 202/265-2752

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. For information: 301/320-3621 or 703/841-4765.

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, judge 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 Workshops 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 JOINT THE NATIONAL CAPITAL ASTRONOMERS

Enclosed is my payment for the following membership category:

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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:

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!**

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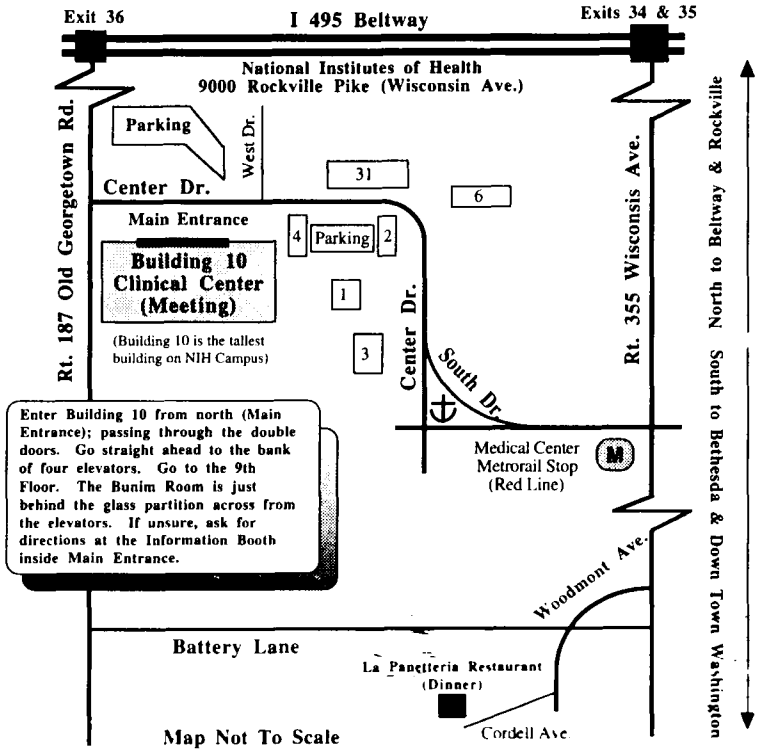
Getting to the NCA Monthly Meeting

Metrorail 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 (walking time about 10 minutes), the tallest 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).

La Posada Restaurant - Take Wisconsin Avenue toward Bethesda and bear right onto Woodmont Avenue (or take the next right onto Battery Lane). Follow Woodmont to Cordell Avenue (2 blocks south of Battery) and make a right at the Thai Place Restaurant. La Panetteria is one block on the right (next corner, 4921 Cordell Avenue). There should be adequate parking on the street outside the restaurant. Seats are not guaranteed after 5:30 PM.



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