Star Dust

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Exploring Interstellar Space With Pickup Ions

Presented by
Dr. George Gloeckler

Reviewed By
Dr. Andrew W. Seacord, II

Dr. Gloeckler's lecture described a new tool that has been used to study the Big Bang creation of heavy elements (nucleosynthesis), and to determine the current density of ordinary matter in the Universe. This tool is a group of interstellar pickup ions (IPIs). IPIs are created from neutral atoms of the interstellar medium that penetrate the Sun's heliosphere, travel to the interior solar system, become ionized by the Sun's radiation, or by collisions with the solar wind, and are collected by a spacecraft-borne detector.

Before discussing IPIs, however, a review of Big Bang nucleosynthesis was presented. Hydrogen is the simplest and, by far, the most abundant element in the Universe. Ordinary hydrogen consists of a single proton surrounded by a single electron. An important isotope of hydrogen is deuterium (chemical symbol, D) which has one neutron added to the nucleus. It is rare in the interstellar medium. The next most abundant element is helium^4 (He^4) whose nucleus contains two neutrons and two protons. A rare, but important, isotope of Helium is He^3 whose nucleus has only one neutron. Lithium^7 (Li^7) was the heaviest element created during the Big Bang. All heavier elements have

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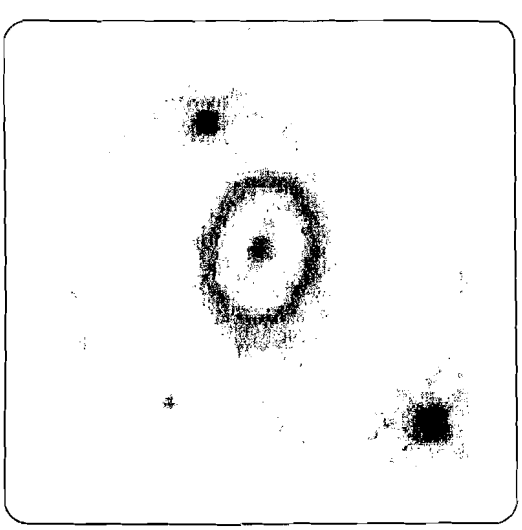
George Sonneborn's Shocking News About Supernova 1987A

submitted by Nancy Byrd

Dr. George Sonneborn, an astrophysicist in the Laboratory for Astronomy and Solar Physics at NASA/Goddard Space Flight Center, will be the featured speaker at the Saturday, March 6, 1999 meeting of National Capital Astronomers (NCA). The title for his talk is "Shocking News About Supernova 1987A in the Large Magellanic Cloud."

Dr. Sonneborn has studied stellar explosions in the form of novae and supernovae since the mid-1980s. He made the first ultraviolet observations of supernova 1987A in the Large Magellanic Cloud and established that the blue supergiant star, Sanduleak -69 202, was in fact the star which exploded to produce this supernova. He studied SN 1987A and its circumstellar material for many years with the International Ultraviolet Explorer satellite, and is continuing that work with the Hubble Space Telescope.

Dr. Sonneborn received his PhD. from Ohio State University is the NASA Project Scientist for the Far Ultraviolet Spectroscopic Explorer mission, scheduled for launch from Cape Canaveral, Florida, in May 1999. O



HUBBLE FINDS MYSTERIOUS RING STRUCTURE AROUND SUPERNOVA 1987A
This striking NASA Hubble Space Telescope picture shows three rings of glowing gas encircling the site of supernova 1987A, a star which exploded in February 1987. Though all of the rings appear inclined to our view (so that they appear to intersect) they are probably in three different planes. The inverted image was taken in visible light (hyrdrogen-alpha emission), with the Wide Field Planetary Camera 2, in February 1994. Credit: Dr. Christopher Burrows, ESA/ STScI and NASA PHOTO CAPTION: STScI-PR94-22 Thursday, May 19, 1994

Calendar of Monthly Events

The Public is Welcome!

NCA Home Page: http://myhouse.com/NCA/home.htm

Mondays, March 1, 8, 15, and 22, 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.

Fridays, March 5, 12, and 19, 8:30 PM - Open nights with NCA's Celestron C–14 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. Call before 6:00 PM.

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

Saturday, March 6, 5:30 PM - Dinner with the speaker, and NCA members at Levante's, 7262 Woodmont Ave., Bethesda, MD. *See* map and directions on back page.

Saturday, March 6, 7:30 PM - NCA meeting, at Lipsett Auditorium in Building 10 at NIH, will feature George Sonneborn, speaking on "Shocking News About Supernova 1987A in the Large Magellanic Cloud" *See* map and directions on back page.

Tuesdays, Closed - Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Classes from November 10th throught April will be cancelled due to construction and will resume in May. Information: Jerry Schnall, 202/362-8872.

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 1998*, the *Observer's Handbook 1998*. 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.

Two Note Worthy Items

I have the NCA audio-visual equipment in my storage shed and I need the space. Can anyone take over storage of this equipment? It's a wooden box approximately 18" x 24" x 32" high. It has wheels and a removable handle. We aren't presently using it because we have all necessary equipment at NIH.

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Regional science fairs will be taking place soon. NCA gives awards to the best astronomy related projects. Winners receive a year's membership in NCA and a year's subscription to Sky and Telescope. NCA members are needed to judge these fairs. Probably the earliest one is the Montgomery County Science Fair. Judging will take place on Saturday, March 20th at NIST in Gaithersburg. If you can assist in judging, contact Jay Miller. Contact Bob Bolster for the Virginia science fairs (703-960-9126). (I'll have to wait until I hear from Jeff Norman about D.C. and I'll have to find out who's doing Prince George's County)

Jay H. Miller
jhmiller@os2bbs.com

Website for Parking at NIH

www.cc.nih.gov/ccc/waytogo/update1.html

Newsletter Deadline for April *Star Dust*, March 15, 1999

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

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been created in stars or, in the case of elements heavier than iron, during the blast of a type II supernova.

The first slide presented was a graph showing the primordial (Big Bang) relative (to hydrogen) abundance of D, He^3, He^4, and Li^7 plotted as a function of the present density of ordinary matter. From this graph, we can obtain the primordial abundance of these four isotopes if we know the present ordinary matter density. Or, if we know the primordial abundance of any one of them, we can, theoretically, determine the present density of ordinary matter as well as the primordial abundance of the other three. Knowledge of the present density of ordinary matter allows us to determine the fate of the Universe. If this density is equal to the critical density, at some time in the future, the Universe will stop expanding and remain static. If it is smaller than the critical value, the Universe will expand forever. If it is larger, the Universe will eventually stop expanding and then contract. Unfortunately, the value of the critical ordinary mass density is not accurately known because it is tied to the value of the Hubble constant, H, whose value is uncertain.

Returning to the abundance plot mentioned earlier, we saw that the abundance of He^4 remains flat at 10 percent regardless of the density of the Universe. Even though He^4 is the second most abundant element in the Universe, it cannot add information about the critical density because its abundance graph is flat with respect to the present density of matter in the Universe. So, we must rely on determining the primordial abundance of D, He^3, and Li^7. This can be accomplished by counting interstellar pickup ions (IPIs).

The next part of the lecture described the interstellar medium and the source of IPIs. Our solar system is surrounded by the interstellar medium (ISM) which is a tenuous gas consisting mainly of atomic hydrogen (not molecular hydrogen) in which are imbedded clouds of denser gas and molecular clouds. The Sun's atmosphere, the solar wind, expands into the ISM with a speed about 500 km/sec carrying the solar magnetic field with it. The expansion speed is supersonic with respect to the ISM, so as the solar wind pushes against the ISM a shock front is created at the boundary of the solar wind and the ISM. This boundary is the heliopause and the region inside it, containing the solar wind and magnetic field, is the Sun's heliosphere. The solar wind speed decreases in the shock front so that it becomes subsonic there.

The size of the heliosphere depends on the density of the interstellar cloud into which it expands. The tenuous gas component of the ISM has a density of about 6 atoms/cubic foot. The density in the clouds imbedded in it are orders of magnitude greater. A few hundred thousand years ago, the Sun entered a low-density cloud having a density of about 6000 atoms/cubic foot. This local interstellar cloud has determined the size of the heliosphere by balancing the solar wind pressure and the cloud pressure. The heliosphere now extends 150 to 200 astronomical units (au) in the direction of the sun's motion through the cloud.

A neutral (i.e. unionized) interstellar gas atom penetrates the heliopause and travels through the heliosphere toward the Sun, unaffected by the solar magnetic field. By the time the atom has reached a distance of about 1 au from the Sun, the Sun's ultraviolet radiation becomes strong enough to drive off one electron, creating an interstellar ion. Ions can also be created by collisions of these atoms with solar wind particles. The ionization time for these ions is about 500 hours. Once the atom becomes an ion, the solar magnetic field exerts a force on it and it is then "picked up" and forced away from the Sun. This ion is, therefore, called an interstellar "pick-up" ion, or IPI. IPIs are swept from a region close to the Sun, forming a cavity with a radius of one or two au.

IPIs can be detected by a spacecraft outside the cavity with the appropriate detector. They can be distinguished from solar wind ions by three characteristics: IPIs are always singly ionized (only one electron removed) whereas non-hydrogen solar wind ions are multiply ionized. Another distinguishing factor is that the flux of IPIs increases with distance from the Sun whereas solar wind flux decreases with this distance. The third distinguishing characteristic - which is the only means of distinguishing IPIs from solar wind ions - is that the distribution of speeds of the IPIs and the solar wind ions are distinctly different.

The Ulysses spacecraft carries the Solar Wind Ion Composition Spectrometer (SWICS), whose data is used to determine the species and the ionization state of each ion collected from the measurement of the ion speed, charge, and mass. The SWICS instrument can distinguish between singly-charged He^3 and He^4 ions, and between a singly-charged He^4 IPI and doubly-charged He^4 solar wind ions. The Ulysses spacecraft is in a heliocentric orbit that is normal to the ecliptic so that the spacecraft passes over both solar poles. Its aphelion distance is 5.4 au.

We were shown a proton (hydrogen ion) density spectrum made from Ulysses SWICS observations at a solar distance of 3 au. It was in the form of a graph of ion "density in velocity space" plotted as a function of W, the ion speed divided by the average solar wind speed; $W = v(ion)/\langle v(solar\ wind)\rangle$. This density spectrum had three regions, each from a different ion population, and illustrates how IPIs can be distinguished from solar wind ions. The first region, between W = 0.4 and 0.8, is the combined spectrum of interstellar ions and ions originating in dust belts close to the sun. The second region, a large feature between W = 0.8 and 1.3 with a peak at W = 1, is the density spectrum of solar wind hydrogen ions. The last region, between W = 1.3 and the sharp drop-off at W = 2, is the density spectrum of IPIs and shows that few IPIs have a speed greater than twice that of the solar wind. This portion of the spectrum provides a means of determining the hydrogen IPI density at a distance of 3 au from the Sun. With this, and knowing the ionization time (500 hours), we can deduce the hydrogen density in the local interstellar cloud. Theoretically, this process can also be applied to the other species, D, He^3, He^4, and Li^7. The abundances of D and He^3 are known to be very low in the ISM, making it difficult to obtain enough ions. There are other ways of estimating the abundance of D, but the abundance of He^3 can only be determined by collecting IPIs.

After more than three years of collecting data with the Ulysses SWICS, there were enough counts to show the

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presence of singly-ionized He^3 pickup ions. The spectrum also showed two distinct populations of He^4, the singly-ionized pickup ion and the doubly-ionized solar wind ion.

The goal is to determine the present density of ordinary matter in the Universe from the primordial (Big Bang) densities of the four species discussed. Dr. Gloeckler demonstrated a graphical approach of estimating the density of the Universe. The abundance ratio of He^3 and deuterium relative to hydrogen, He^3/H and D/H, were plotted, with error bars, as a function of time, starting with the present time on the left and ending with the Big Bang, assumed to be 13 billion years (By) ago, on the right. The present abundance of He^3 was obtained from pickup ions. The present abundance of deuterium was estimated from Hubble Space Telescope observations of absorption spectra of nearby stars.

The only other time between the present and the Big Bang at which abundances can be estimated is the time at which the solar system was formed 4.6 By years ago. Since there are no nuclear processes on Jupiter to destroy D and He^3, their abundances in the Jovian atmosphere are assumed to have not changed since Jupiter's formation. Therefore, D/H and He^3/H at 4.6 By were determined from recent Galileo spacecraft observations of the Jovian atmosphere.

The primordial abundance ratio D/H was estimated from absorption spectra from very distant, hence very old, ISM clouds observed with the 10 meter Keck telescope in Hawaii. The observations are, however, difficult to interpret; therefore, there are large error bars associated with this estimate. No measurements of primordial He^3 are available. Consequently, a range of primordial He^3/H abundance was determined by graphically extrapolating the plot from the present and 4.6 By values to 13 By.

Dr. Gloeckler applied these primordial values of D/H and He^3/H to his original graph that related primordial abundance ratios He^4/H, D/H, He^3/H and Li^7/H to present ordinary mass density of the Universe. The result was a range of values for the present density of ordinary matter; the lower bound of about 1.1×10^{-31} g/cubic cm comes from He^3/H and the upper bound of about 4.6×10^{-31} g/cubic cm comes from D/H. The current estimates of the critical density range from 6.0×10^{-30} to 1.0×10^{-29} g/cubic cm. So, from this analysis, one might conclude that the current density of ordinary matter in the Universe is more than an order of magnitude less than that required to halt the expansion. Will the Universe actually expand forever? Dr. Gloeckler said that it may not expand forever because the amount of missing mass may be enough to close the Universe.

Dr. Gloeckler returned to the Sun and discussed the effect of the density of the local interstellar cloud on the size and shape of the heliosphere. Before the Sun entered this cloud a few hundred thousand years ago, it traveled through the intercloud gas whose density was about 6 atoms per cubic foot, about a thousand times lower than the density in the present local interstellar cloud. Due to the lower outside pressure, the heliosphere was much larger a few hundred thousand years ago than it is today. Its size then was determined more by forces exerted by the galactic magnetic field [a few microgauss] than by the pressure of the interstellar gas. Interstellar clouds range in size between 5 and 10 au and can have mass densities between 30 and 500 thousand times that of the present local interstellar cloud. If the Sun were to enter such a dense cloud - as it probably will do some time in the future - the heliosphere would collapse under the pressure of the cloud to a size of 1 au or less. This will place the Earth outside the heliosphere and into the interstellar medium. This will have a profound effect on life here on Earth.

As the final topic of his lecture, Dr. Gloeckler discussed future interstellar space missions. He discounted sending a spacecraft 300,000 au to the nearest star because the propulsion technology to do so does not exist today. However, he believes that the present technology will allow us to place a spacecraft at a distance of 1,000 au, or so, from the Sun, which is well outside the heliosphere. In fact, NASA is now studying such a mission, the Interstellar Probe, which could be launched in the next 15 to 25 years. The travel time to the observing position 1000 au from the Sun would be several decades.

He also suggested another mission, the "Interstellar Pathfinder" which would place a spacecraft at a solar distance between 3 and 5 au. Present instrument technology will provide a sensitivity, or collecting power, of 500 times that of the Ulysses SWICS. This mission would be able to determine the interstellar He3 abundance with a much smaller error than that of the present estimate used in the analysis described earlier. This mission would also allow the detection of interstellar deuterium pickup ions as well as the determination of elemental and isotopic abundance if interstellar nitrogen, oxygen, neon, and argon. The results will be applicable to stellar evolution models and will provide answers to key questions concerning the sun's interstellar environment.

Finally, Dr. Gloeckler summarized the goals of the Interstellar Pathfinder mission as follows:

1. Determine the composition of the interstellar medium and what it tells us about the birthplace of the sun and the evolution of our galaxy and Universe.

2. Determine the physical state of the local interstellar cloud and the nature of the sun's heliosphere interactions with it.

3. Construct an image of the termination shock using energetic neutral atoms as "messengers" and, from this image, determine the characteristics of the shock region.

4. Explore the region close to the sun by the collection of pickup ions created from neutral atoms which originate there.

5. Determine the nature of the interaction between pickup ions and the solar wind.

For a conclusion, we were reminded that Voyager 1 will cross the heliopause termination shock in the near future - probably before the proposed missions begin - and will become the first human-made object to leave our solar system. We thank Dr. Gloeckler for a very interesting and informative presentation. ○

Total Occultations in the Mid-Atlantic States Region

by David Dunham

Total Lunar Occultations

DATE	Day	EST	Star	Mag	%	alt o	CA	Notes
Mar 8	Mon	3:30	R ZC 2231	6.8	68-	34	9N	
Mar 9	Tue	1:29	R ZC 2352	6.9	60-	12	82S	Possible close double
Mar 13	Sat	4:37	R ZC 2908	6.9	21-	9	81N	Pos. close dbl.; az. 124 deg.
Mar 22	Mon	11:46	D Aldebaran	0.8	31+	22	65N	az. 86 deg.; Sun alt. 51 deg.
Mar 22	Mon	12:45	R Aldebaran	0.8	32+	34	-87N	Sun alt. 51 deg.
Mar 22	Mon	23:13	D ZC 741	5.5	35+	9	26S	Pos. close dbl.; az. 264 deg.
Mar 23	Tue	19:45	D SAO 094899	7.8	44+	59	80N	
Mar 23	Tue	20:12	D ZC 0884	7.8	45+	54	9N	Graze, Martnbg, WV-Baltimore, MD
Mar 23	Tue	21:18	D SAO 094943	7.9	46+	42	19N	Graze, Shpnsbg, PA-Conowingo, MD
Mar 25	Thu	18:34	D 81 Gem	4.9	67+	65	87S	Sun alt. -3 deg.
Mar 29	Mon	22:10	D sigma Leo	4.1	97+	55	30S	= ZC 1644

"D" following the time denotes a disappearance, while "R" indicates that the event is a reappearance. The times are for Greenbelt, MD, and will be good to within +/-1 min. for other locations in the Washington-Baltimore metropolitan areas unless the cusp angle (CA) is less than 30 deg., in which case, it might be as much as 5 minutes different for other locations across the region. "Mag" is the star's magnitude. "%" is the percentage of the Moon's visible disk that is sunlit, followed by a plus (+) indicating that the Moon is waxing and a minus (-) showing that it is waning.

Planned Grazing Occultation Expeditions

DATE	Day	EST	Star	Mag	%	alt	CA	Location
Mar 8	Mon	1:49	gamma Lib	3.9	69-	23	12S	Hartford, CT; possible double
Mar 23	Tue	19:50	SAO 094883	7.8	44+	58	1S	Martinsburg, WV & Baltimore, MD
Mar 23	Tue	20:16	ZC 0884	7.8	45+	54	0N	Darkesville, WV & s. Columbia, MD
Mar 23	Tue	21:27	SAO 094943	7.8	45+	41	2N	Shippensburg, PA & Conowingo, MD

Asteroidal Appulses

DATE	Day	EST	Star	Mag	Asteroid	dmag		s	in.	Location
Mar 3	Wed	1:26	SAO 079750	9.7	Selene	5.0	14	5		Texas
Mar 22	Wed	1:00	ACT07731067	10.6	Asterope	2.8	19	7		s. Virginia
Mar 23	Thu	2:54	ACT67520211	9.9	Lachesis	2.7	39	6		Dakotas, Winnipeg
Mar 26	Sun	22:04	CRS 4951	11.9	Eugenia	1.6	9	10		Maryland, n. VA
Apr 2	Fri	19:44	SAO 078480	7.7	Eurydike	7.1	3	2		Massachusetts
Apr 3	Sat	5:21	SAO 119282	7.6	Hermione	5.4	14	2		Texas, s. Florida

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Phone the IOTA occultation line, 301-474-4945, for updates and details, or check IOTA's Web site at http://www.sky.net/~robinson/iotandx.htm For asteroidal occultations, finder charts can be found at http://members.home.net/dega/astchart.htm.

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

Department of Terrestrial Magnetism, Carnegie Insititue of Washington —

Seminars are all at 11:00 am and are generally held on Wednesdays (unless otherwise noted by **) in the Seminar Room of the Main Building

"Formation of the Earth/Moon System", Speaker, Robin M. Canup, March 10.

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 — "Rights of Spring: Vernal Equinox", March 20, 7:00 PM.

NASA Goddard Scientific Colloquia — All Colloquia will take place in Bldg. 3 Auditorium, with coffee and cookies at 3:30.

"Exploring the Giant Planets with Hubble Space Telescope", Speaker Heidi Hammel, March 5.

"Comets, Planets, and the Sky: Italy's Roots in Space", Speaker, Giovanni Bignami, March 10.

"New Findings from the Mars Orbiter Laser Altimeter", Speaker, Dave Smith, March 12.

"Growing Crystals in Microgravity", Speaker Dan Cater, March 26.

Meteor Showers

Major Activity

Radiant	Duration	Maximum
None		

Minor Activity

Radiant	Duration	Maximum
Eta Draconids	March 22-April 8	March 29-31
Beta Leonids	Feb. 14-April 25	March 29-31
Rho Leonids	Feb. 13-March 13	March 1-4
Leonids-Ursids	March 18-April 7	March 10-11
Delta Mensids	March 14-21	March 18-19
Gamma Normids	March 11-21	March 16-17
Eta Virginids	Feb. 24- March 27	March 18-19
Pi Virginids	Feb. 13-April 8	March 3-9
Theta Virginids	March 10-April 21	March 20-21

Daylight Activity

Radiant	Duration	Maximum
March Aquarids	Feb.-April	March 15-18

SPACE EXPLORATION AT THE MILLENNIUM

In Remembrance of Carl Sagan

A part of NASA's
40th Anniversary Celebration

All day, Wednesday, March 24, 1999 at American University, Washington, DC

The symposium is free and open to the public, but seating is limited. Seats will be allocated in the order in which reservations are made.

* PLEASE REGISTER EARLY *

Panelists:
Buzz Aldrin, Avery Brooks, Yvonne Cagle, Andrew Chaikin,
Franklin Chang-Diaz, Ann Druyan, Timothy Ferris, Lou Friedman,
Don Herbert, Bill Nye, Fred Ordway, Kim Stanley Robinson,
Donna Shirley, Edward Stone, Kathy Sullivan and Jill Tartar

Panel Moderators:
Hugh Downs, Ted Koppel, John Logsdon, Howard McCurdy and Ned Potter

Featured Speaker: Daniel Goldin

For more information about this symposium, access the web site:

www.space2000.org

You may register on-line. The registration form will be taken off of the web site when seats at the symposium run out.

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 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*. ($54 per year)
- [ ] Star Dust only ($27 per year)

[ ] Junior (Only open to those under age 18) Date of birth: _____
- [ ] *Sky & Telescope* and *Star Dust*. ($42 per year)
- [ ] Star Dust only ($15 per year)

_____ _____ (____) _____ _____

First name(s) Last name Telephone E-mail

_____ _____ _____ _____ _____-_____

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!**

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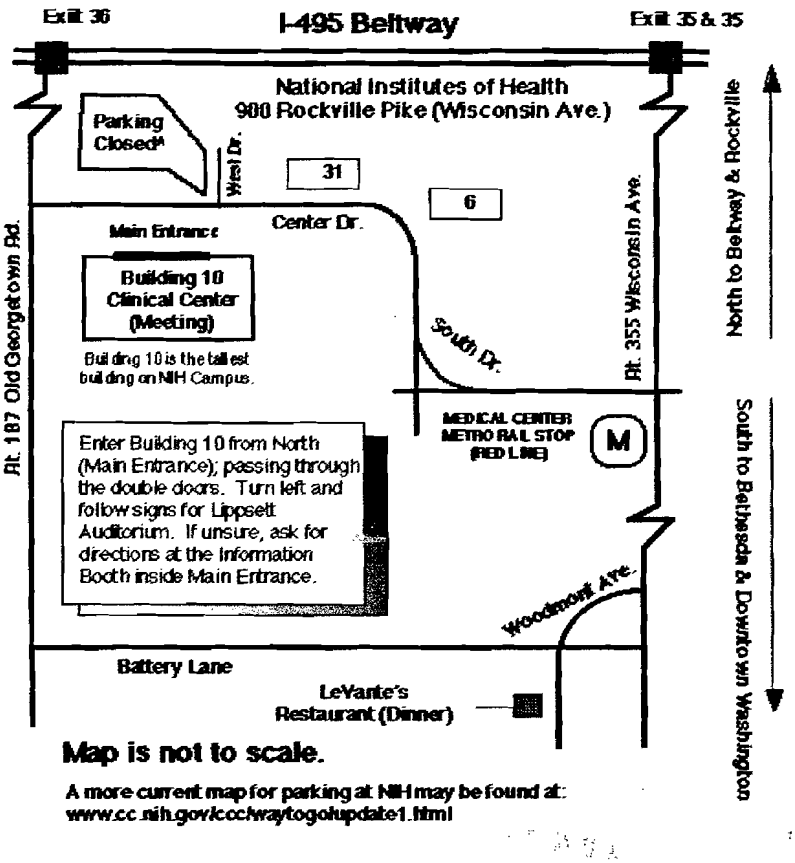
Getting to the NCA Monthly Meeting

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 Levante's Restaurant - From the beltway, take Wisconsin Avenue toward Bethesda and turn right onto Woodmont. Follow Woodmont. The restaurant is at 7262 Avenue (301/657-2441). There are parking garages nearby. Seats are not guaranteed after 5:30 PM.



Map is not to scale.

A more current map for parking at NIH may be found at: www.cc.nih.gov/ccc/waytogolupdate1.html

***Star Dust* is published ten times yearly (September through June) by the National Capital Astronomers, Inc. (NCA), a nonprofit, astronomical organization serving the entire National Capital region, and beyond. NCA is the astronomy affiliate of the Washington Academy of Sciences and the National Capital region's representative of the International Dark-Sky Association. President: Andrew Seacord, 301/805-9741. Deadline for *Star Dust* is the 15th of the preceding month. Editors: Alisa & Gary Joaquin, 4910 Schuyler Dr., Annandale, VA 22003, 703/750-1636, E-mail: ajglj@erols.com. Editoral Advisor: Nancy Byrd**

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