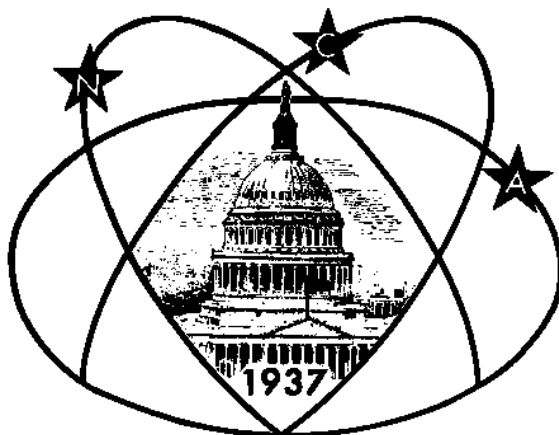


# Star



# Dust

National Capital Astronomers, Inc.

Volume 58, Number 8

April, 2000

ISSN 0898-7548

## Judith Lean to Talk on the Role of the Sun in Global Change and Space Weather

*submitted by Nancy Byrd*

Dr. Judith Lean will present the featured talk for the April 1, 2000 meeting of National Capital Astronomers (NCA). The April meeting will be held in the Lipsett Auditorium in Building 10 (Clinical Center) of the National Institutes of Health in Bethesda at 7:30 PM. Dr. Lean is a research physicist in the Space Science Division of the Naval Research Laboratory and is perhaps the world's most knowledgeable on the relation between solar variation and its terrestrial effects. Her talk is entitled "The Role of the Sun's Electromagnetic Radiation in Global Change and Space Weather." Dr. Lean writes the following about her topic: "The Sun's electromagnetic radiation makes our planet habitable. Its energy at visible and infrared wavelengths heats the Earth's surface and powers the climate system. Without solar ultraviolet radiation, the ozone layer that protects the biosphere from harmful short-wavelength radiation would not exist. Solar radiation in the EUV and X-ray spectrum controls the temperature and composition of the Earth's upper atmosphere and

ionosphere, regions of our extended environment of increasing importance for commerce and defense.

"While the Sun has long been a reliable source of the radiant energy for the Earth, its radiation is not constant. Changes occur continuously at all wavelengths of the spectrum. Space-based measurements during the past 20 years have detected 11-year cycles upon which are superimposed short-term changes associated with the Sun's 27-day rotation on its axis. (The solar cycle variations range from 0.1% in the visible spectrum to orders of magnitude higher in the X-ray spectrum.) Indirect "proxies" of solar activity (from tree-rings and ice-cores) that have 11-year cycles like the radiation, exhibit longer-term changes that exceed the amplitudes of their 11-year cycles. Comparisons of these proxy records with direct observations suggest that present levels of solar irradiance are likely increased relative to periods of anomalously low solar activity in the recent past, such as the seventeenth century Maunder

Minimum.

"Our terrestrial environment exhibits many signatures of apparent solar origin. Climate parameters often have cycles in common with solar activity proxies, such as near 11, 22, 80 and 210 years. Times of cooler climate in past millennia usually coincide with reduced levels of solar activity.

"Aspects of solar electromagnetic radiation variability and their terrestrial effects will be discussed on a range of time scales, illustrating the societal impacts of different spectral regions. Detection of climate change and ozone depletion requires reliable specification of solar-induced processes that may mask or exacerbate anthropogenic effects. Pre-industrial Sun-climate associations suggest that some 30% of surface warming in the past century may be solar-related. Solar-induced fluctuations in global ozone concentrations rival the depletion by chlorofluorocarbons during recent decades. Communications and navigation for commerce, industry, science and

*(Continued on page 2)*

## Recent and Future Advances in Astrometry

*by Wayne H. Warren Jr.*

At their March 4, 2000 monthly meeting, NCA members and guests were pleased to hear a lecture about the discipline of positional astronomy, as given by Dr. Kenneth J. Johnston, the Scientific Director of the United States Naval Observatory (USNO) in Washington, D.C. Dr. Johnston is well known to long-time NCA members, having given us a lecture about long baseline optical interferometry on November 5, 1988 (see the review of his talk by Robert H. McCracken in the December 1988 *Star Dust*, Vol. 46, No. 4), while he was Chief of the Radio and Infrared Astronomy Branch at the Naval Research Laboratory (NRL).

Astrometry is the astronomy of star positions, meaning that the data of astrometry include not only the positions themselves (i.e., right ascension and declination), but also related information such as space motions and parallaxes. Space motions are the actual motions of the stars themselves in three dimensions; these are composed of proper motions (the transverse motions on the plane of the sky in angular units) and radial (or line-of-sight) velocities toward or away from the observer. The latter are usually expressed in  $\text{km s}^{-1}$  and referred to the Sun; i.e., they are corrected for the position and velocity of the Earth with re-

*(Continued on page 2)*

## Zip Codes Zapped

*by Nancy Grace Roman*

Sometime since the mailing of the March *Star Dust*, I corrupted the NCA database by changing all "4"s to "9"s. I do not know if it was before or after I printed the March directories. If you renewed between the last two meetings, you received a directory dated March. Please check it. If it is corrupted, please let me know and I shall replace it. If you do not have a 4 in your address, check the entry for Benjamin Adelman who lives at 4211 Colie Drive. Also, since I made the corrections one by one, I may have missed some. Please check your *Stardust* address label and your renewal notice carefully when you receive them.

I thank Wayne Warren for alerting me to this problem.

## NCA Events This Month

The Public is Welcome!

NCA Home Page: <http://capitlastronomers.org>

**Fridays, April 7, 14, 21, 28, 6:45 - 9:30 P.M.** Telescope-making classes at American University, McKinley Hall Basement, Nebraska and Massachusetts Avenues, Washington, D.C. However, on April 7 and 28, if the weather is clear, there might not be a class, because the moon will be near new and the instructor may be out stargazing. Call or e-mail to confirm on those dates. Information: Guy Brandenburg, 202-635-1860, or [gbranden@earthlink.net](mailto:gbranden@earthlink.net)

**Fridays, April 7, 21, 28, 9:00 P.M.** - Open nights with NCA's 14-inch telescope at Ridgeview Observatory near Alexandria, Virginia; 6007 Ridgeview Drive (off Franconia Road between Telegraph Road and Rose Hill Drive). Call Bob Bolster, (703) 960-9126 before 6:00 P.M. Note 9:00 P.M. start!

**Saturday, April 1, 5:30 P.M.** - Dinner with the speaker and NCA members at the Sushi Chalet, 4910 Fairmont Ave., Bethesda, MD. See map and directions on Page 8.

**April 1, 7:30 P.M.** - NCA meeting, at Lipsett Auditorium in Building 10 at NIH, will feature Dr. Judith Lean, NRL, speaking on "The Role of the Sun's Electromagnetic Radiation in Global Change and Space Weather".

**Saturday, April 29,** beginning 6:00 P.M. - Open House at Hopewell Observatory. See the article on Page 4 for directions.

See Page 6 for more National Capital area astronomical doings. To join NCA, use the membership application on Page 9.

## Astrometry, continued

(Continued from page 1)

spect to (wrt) the Sun at the time of observation and known as heliocentric radial velocities. Although parallax itself is not a motion, it is needed to convert the angular measure of space motion to actual velocities. Thus, a star's astrometric data, when known accurately, tell us exactly where the star is wrt the Solar System at a given time (epoch) and how it is moving. This in turn tells us a lot about the star itself, such as how the star is moving wrt the center of the Galaxy, whether it is a population I (low, solar-type velocity) or population II (high velocity, older object), and, combined with other information, the physical nature of the object. Until rather recently, stellar motions could not be determined very accurately except for the closest stars, say, nearer than about 10 parsecs (1 pc = 3.26 ly). (The closest solar neighbor is the  $\alpha$  Centauri system at a distance of 1.3 pc).

Dr. Johnston began his talk by showing the history of accuracy in positional astronomy. Prior to the invention of the telescope, positions could not be determined to better than about a minute of arc. Telescopic measurements and the use of the photographic plate increased the accuracy to roughly 0.02 seconds of arc, but the Earth's atmosphere became a limiting factor until optical interferometry from the

ground and astrometry from space have pushed the current accuracy to about 0.001 seconds of arc (or a milliarcsecond [mas] or arcmillisecond). Future space missions claim to be able to extend this accuracy to the microarcsecond ( $\mu$ as) range using conventional drift scan techniques and space interferometry. Considering the angles being measured here, this is mind boggling. A few analogies will clarify the point: viewed from a distance of 1 meter, human hair grows at an average rate of 2 mas  $s^{-1}$ , while a millisecond of arc is the angle subtended by a car's headlights in San Francisco as measured by an observer on the east coast of the US.

The situation in radio astronomy was very poor in the early days of that discipline (the forties and fifties) because beam sizes were large. Radio interferometry has now leveled the playing field and long baseline measurements (VLBI) have surpassed the optical in some cases. For example, the positions of some quasars (QSOs or quasi-stellar objects) are known to an accuracy of about 250  $\mu$ as. In fact, the positions of a group of quasars are known so accurately that they are used to define the newest astrometric reference frame, known as the International Celestial Ref-

(Continued on page 3)

## Role of the Sun, continued

(Continued from page 1)

defense rely on satellite signals transmitted through, and reflected by, electrons in the ionosphere whose densities respond to solar radiation variations. Spacecraft and space debris experience enhanced drag on their orbits when changing EUV radiation causes upper atmosphere densities to increase. Especially affected are spacecraft and debris in lower altitude orbits, such as Iridium-type communication satellites, and the International Space Station (ISS)."

## Dangerous Space Weather

by Elliott Fein

I had just received my copy of *Space Science News for March 22, 2000* by e-mail, when a glance at the first article caught my eye.

It said: "The Earth's magnetosphere is being buffeted by high-speed solar wind particles from a coronal hole straddling the center of the Sun's disk. The solar wind velocity has increased from 350 to 600 km/s during the past 12 hours. Follow the action at <http://www.spaceweather.com>"

Given the topic of the upcoming talk on April 1, I couldn't resist clicking on that URL. Well, I was then in the thicket of a plethora of information and pictures (and more URLs) on, what else, space weather. For example:

### SPACE WEATHER

#### Current Conditions

##### Solar Wind

velocity: 537.8 km/s

density: 3.9 protons/cc.

More about these data

Updated: Today at 1916 UT

I stopped counting at 37 URLs. I was buried in solar winds, coronal holes, sunspots, geomagnetic storms and solar flares. I couldn't stop looking and clicking. (And here, Adele thought I was working on this newsletter!)

Today, March 23, the Solar Wind Velocity had increased to 546.0 km/s but the density had decreased to 5.0 protons/cc (at 1945 UT). I don't know whether to be relieved or upset about these developments.

If you want to avoid catching the "space weather flu" and other Space Science diseases, don't go to <http://spacescience.com/news/subscribe.htm>.

## Astrometry, continued

(Continued from page 2)

reference Frame (ICRF), recently adopted by the International Astronomical Union (IAU) to replace the earlier optical frame based on the *Fifth Fundamental Katalog* (FK5).

Source positions given in the ICRF are said to be on the system ICRS, as defined by a collection of 212 radio sources based on measurements by GSFC astronomer Chopo Ma and his colleagues (see, for example, Ma et al. 1990, *AJ*, 99, 1284; Johnston et al. 1995, *AJ*, 110, 880; Ma et al. 1998, *AJ*, 116, 516; *AJ* is *Astronomical Journal*) in support of Goddard's Geodynamics project to measure the motions of the Earth's continents. The ICRF has its origin at the barycenter of the Solar System, with the right ascension currently defined by the QSO 3C273 (the brightest object of its class). The accuracy of the frame is now about 20  $\mu$ as.

The great advantage of a reference frame based on extragalactic sources at cosmological distances is that they define a very stable inertial frame that is essentially motionless. An important disadvantage of many of the radio sources is that they exhibit structure below about 0.005". Thus, they are not really point sources and the accuracy is somewhat compromised. The sources chosen to define the ICRF are therefore selected from a larger pool based on their observed structure.

Dr. Johnston next turned to the recent contributions of optical astronomy to the refinement of positions and motions. The European Space Agency's HIPPARCOS (High Precision PARallax Collecting Satellite) mission was launched in 1989 and flew for approximately 3.5 years. The principal experiment, called Hipparcos, measured high accuracy positions, proper motions, parallaxes, and photometric data for approximately 118,000 stars, while a secondary lower accuracy survey instrument named Tycho measured an additional 1 million stars (asteroids were measured as well). The former achieved an overall accuracy of about a milliarcsecond in position and 2 mas yr<sup>-1</sup> in proper motion, the latter closer to 0.025" and  $\geq 0.03$ " yr<sup>-1</sup>, respectively. The Hipparcos data have literally revolutionized the discipline of positional astronomy and have had a major impact on astrophysics, improving the calibration of the Hertzsprung-Russell diagram, the stellar temperature and luminosity scales, interstellar absorption in the solar neighborhood, and many other parameters. However, because of errors in the proper motions, positional and proper-motion errors increase as one moves away from the epoch of observation. This is much less of a problem for the radio

sources, since they are so far away as to have essentially no detectable proper motions except over long periods of time.

Meanwhile, much progress has been made with ground-based instruments as well. The most recent collaborative effort of USNO and NRL is an optical instrument built on Anderson Mesa outside Flagstaff, Arizona. This is the NPOI (Navy Prototype Optical Interferometer), which is currently in operation and undergoing further enhancements. (Dr. Donald J. Hutter described this instrument, in its earlier phases, to NCA members at the September 1993 meeting [see the November 1993 issue of *Star Dust*]). Results from the instrument can be found in papers by Hummel et al. 1998 (*AJ*, 116, 2536) and by Nordgren et al. 1999 (*AJ*, 118, 3032).

An interferometer can be used to compensate for atmospheric distortion by observing multiple wavefronts, then introducing a delay in one of the paths using a Michelson interferometer. The resolution is determined by the length of the baseline between the receivers. Short baselines are used to measure stellar positions, while long baselines are capable of actually imaging stellar surfaces, which tend to be in the milliarcsecond range for the brighter stars. Supergiant stars that are not too distant from the Sun can have considerably larger angular diameters; e.g., Antares has an angular size of 0.040", while the Mira-type variable star R Leonis is a whopping 0.062" in angular diameter.

Optical interferometry is proving so valuable that several groups are now building arrays. The Australian group that built one of the first stellar interferometers, the Narrabri Observatory Intensity Interferometer, which measured angular diameters for many nearby early-type stars in the late 1960s, is building SUSI (Sydney University Stellar Interferometer).

The CHARA (Center for High Angular Resolution Astronomy) group at Georgia State University, which has done much of the speckle interferometry accomplished over the last two decades, has built an optical array on Mount Wilson Observatory, the same site at which Michelson and Pease first installed an interferometer on the 100-inch Hooker telescope and measured an angular diameter for  $\alpha$  Orionis (Betelgeuse) in 1921. An optical array called COAST is also under construction in Cambridge UK by the Institute of Astronomy, University of Cambridge. All of these arrays are designed to either image stellar surfaces or to measure very close binary stars for purposes of determining orbits and masses for many more stellar types than are presently available.

Dr. Johnston went on to describe the NPOI

in more detail, explaining some of the new work that the instrument will do. The images from the array telescopes travel to a central building where delays are inserted. The difficulty of the technique lies with the critical spacing of the mirrors, which must be accurate to 0.1  $\mu$ m for seventeen reflections to realize the potential of the instrument. The current accuracy is about 1  $\mu$ m, corresponding to a positional accuracy of 10 mas. The inner part of the array is now operating with three telescopes, with six telescopes expected to be in operation by this coming summer. Applications of the interferometer include the measurement of stellar angular diameters, which, when combined with distances, can yield physical dimensions; very accurate determinations of binary orbits by measuring relative positions of orbiting components (e.g., *Mizar* and *o Leonis*); and measurements of the changing radii of pulsating stars like  $\delta$  Cephei. The correlation of brightness changes with radius should provide a very accurate picture of how Cepheid and other pulsating stellar luminosities change with physical size.

Dr. Johnston also mentioned an ongoing NASA project to build an interferometer on the Keck telescopes on Mauna Kea, to become operational in about 1.5 years. Additional 1.8-meter outrigger telescopes will be constructed later to complete the interferometric array. This interferometer is being constructed primarily to look for additional planets around nearby stars.

Many of the limitations of ground-based measurements can be overcome by going into space. The rest of Dr. Johnston's talk was concerned with the collaborative FAME (Full-sky Astrometric Mapping Explorer) mission of USNO, NRL, Lockheed Martin Aerospace, and the Smithsonian Astrophysical Observatory (SAO) in Cambridge MA. FAME is not an interferometer. It uses a large CCD array and measures relative positions by drift scanning, much in the same way as did HIPPARCOS.

FAME will perform an all-sky astrometric survey, measuring about 40 million stars, with completeness to about magnitude 15.

Accuracies will range from  $\leq 50$   $\mu$ as for stars from fifth to ninth magnitude, to about 500  $\mu$ as at fifteenth magnitude. The nominal mission lifetime is 5 years. In addition to the astrometric data, FAME will measure stellar magnitudes in four photometric bands that have become standard through their use with the Sloan Digital Sky Survey. These are the Gunn bands known as *u'* (uv, 350/60 nm), *g'* (blue-green, 480/140 nm), *r'* (red, 625/140 nm), *i'* (far red, 770/150 nm), and *z'* (near-IR, 910/120 nm), where the pairs of numbers

(Continued on page 4)

## Astrometry, continued

(Continued from page 3)

are the central wavelength and width of each filter.

The FAME instrument will have a large focal plane containing 24  $2K \times 4K$  CCDs. The field of view will be about 1 degree in size so that hundreds of stars can be measured simultaneously. Global solutions for all observations will produce a catalog of mission data expected to be available one year after the mission ends. Since launch is not scheduled until 2004, the final catalog is not expected until about 2010.

What can we expect to learn from the FAME mission? The breadth of information that will become available is enormous. While the Hipparcos instrument produced an accuracy of 1 mas, corresponding to reliable distances out to 100 pc, FAME, on the other hand, with an accuracy of 50  $\mu$ as, will produce reliable distances out to 2 kpc, thus encompassing enough volume to produce accurate distances and photometric luminosities for every kind of star. This will have profound consequences for our knowledge of stellar evolution and structure and will pave the way for future missions that will map the entire visible Milky Way Galaxy. The large number of observations by FAME is also expected to produce reliable distances to the Magellanic Clouds, the distances of which have not heretofore been determined by astrometric methods.

Summarizing probable results from the FAME mission, Dr. Johnston mentioned the following:

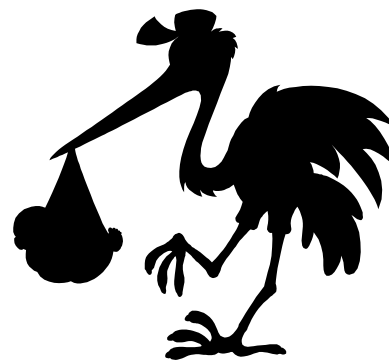
- improved knowledge of stellar structure and evolution through accurate luminosity and temperature calibrations for every kind of star known
- improvement in the extragalactic dis-

tance scale from more accurate distances to Cepheids and RR Lyrae stars

- accurate motions of stars in the galactic disk, with possible implications for dark matter studies
- detection of more brown dwarfs and extrasolar giant planets
- stellar variability studies at the milli-magnitude level and studies of solar analogs to learn more about the evolution of the Sun itself
- accurate distances and calibrations for star clusters, where stellar evolution is best studied in coeval stars of various masses

In concluding his talk, Dr. Johnston touched upon the SIM, which will fly after FAME. SIM is a pointed mission that will examine some 10,000 stars for evidence of planetary companions. The accuracy of SIM's observations is expected to be 4-30  $\mu$ as for large angles and close to 1  $\mu$ as for small angles (such as close binary stars).

The FAME, SIM, and GAIA missions give us much to look forward to in understanding the Universe and the objects in it. Until recently, astrometry was considered to be the bailiwick of a bunch of old geezers measuring parallax after parallax. It was not considered to be of much relevance to the more prestigious disciplines of astrophysics and cosmology. That has changed with the advent of new technology that makes possible highly accurate astrometric observations. We always knew that the determination of accurate distances to astronomical objects would be the Rosetta Stone of astrophysics and cosmology — we just didn't know how to do it. The present and future astrometric missions provide a giant step toward achieving our goal of really understanding the Universe in



by Nancy Byrd

Alisa Joaquin, former editor of *Star Dust*, and her husband, Gary Joaquin, a frequent contributor to *Star Dust*, have a new addition to their family. Her name is Lynne Faye Joaquin; she was born on Thursday, March 9 at 7:37 PM.

which we live.

The NCA is indebted to Dr. Johnston for sharing his knowledge and insight with us. This material was composed with the help of my own audio tape and a video tape made and copied for me by Dick Byrd. I thank him for that effort. I also thank Dr. Johnston for reviewing the text and making comments.

## Open House at Hopewell Observatory

by Bob Bolster

NCA members, families, and guests are invited to view the spring sky at Hopewell Observatory on Saturday evening April 29. Sunset will be at 20:02, astronomical twilight ends at 21:42. If you wish, come any time after 6:00 P.M. and bring your prepared picnic dinner. Coffee, tea, and cocoa will be provided by the Hopewell Corporation.

Directions: (1) From the Beltway (I-495) go west on I-66 25 miles to Exit 40 at Haymarket onto U.S. 15. (2) Turn left on U.S. 15 at the end of the exit ramp. (3) Go 0.3 miles to the traffic light, turn right onto Va. 55. (4) Go 0.8 miles to Antioch Road (Rt. 681) and turn right. (5) Go 3.2 miles to the

end of Antioch Rd. and turn left onto Waterfall Road (601). (6) Go one mile and bear right onto Bull Run Mountain Rd. (Rt. 629).

(7) Go 0.9 miles on 629 to a narrow paved road at right with an orange pipe gate. (Directly across from an entrance gate with stone facing.) (8) Turn right through the pipe gates, go 0.3 miles to the top of the ridge, and around the microwave station. (9) Continue on dirt road through the white gate and woods a few hundred feet to the observatory. Park along the road short of the buildings. Canceled if raining or hopelessly cloudy. For further information, call (703) 960-9126.

**Deadline for  
May *Star Dust*.  
April 15**



Please send submissions to Elliott Fein at [elliott.fein@erols.com](mailto:elliott.fein@erols.com).

**Text must be in ASCII or Word. Graphics submitted must be in BMP, TIFF, GIF, or JPEG.** Thank you.

# Mid-Atlantic Occultations and Expeditions

April 2000

by David Dunham

## Asteroidal Occultation

DATE	Day	EDT	Star	Mag	Asteroid	dmag	Dur Ap.	s in.	Location
Apr 18	Tue	21:47	SAO 095408	9.8	Wratislavia	4.0	5	5	Carolinas

## Grazing Occultations

DATE	Day	EDT	Star	Mag	% alt	CA	Location
Apr 10	Mon	22:00	SAO 079005	7.7	43+	46	2N Gaithersb., Greenbelt, Bowie, MD
Apr 10	Mon	22:38	zeta Gem	4.0	44+	37	-2S Media, PA; s. NJ

Note: See more information about the SAO 079005 graze at the bottom of the page. We will try zeta Gem only if the weather prospects are much better northeast of the DC area. The zeta Gem graze events will be mainly among sunlit lunar features and thus hard to observe.

## Total Lunar Occultations

The better total lunar occultations through early May visible from throughout the Washington-Baltimore greater metropolitan area are listed below. Most can be accurately timed by aiming a camcorder into a low-power eyepiece of your telescope and recording WWV with the audio.

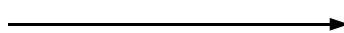
DATE	Day	EDT	Star	Mag	% alt	CA	Notes
Apr 9	Sun	22:12	D SAO 77889	6.9	33+	33	79N Sp. type G5
Apr 10	Mon	21:03	D SAO 78993	7.8	44+	56	67S Sp. type A2
Apr 10	Mon	22:00	G SAO 79005	7.7	44+	46	2N Many min. earlier s. of n. limit
Apr 10	Mon	22:51	D SAO 79059	7.8	44+	37	49N Sp. type G5
Apr 11	Tue	19:57	D ZC 1205	6.3	55+	71	33S Sp. type K1; Sun alt. -4 deg.
Apr 15	Sat	23:42	D ZC 1709	6.6	93+	56	70N Sp. type K0
Apr 23	Sun	5:37	R 58 Oph	4.9	80-	28	43S ZC 2547; pos.close dbl; Sun -9
Apr 25	Tue	5:21	R 50 Sgr	5.6	63-	28	13N ZC 2838; pos.close dbl; Sun-11

D following the time denotes a disappearance, while R indicates that the event is a reappearance. When a power (x; actually, zoom factor) is given in the Notes, the event can probably be recorded directly with a camcorder of that power with no telescope needed. 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 percent of the Moon's visible disk that is sunlit, followed by a + indicating that the Moon is waxing or - showing that it is waning. So 0 is new moon, 50+ is first quarter, 100+ or - is full moon, and 50- is last quarter. The Moon is crescent if % is less than 50 and is gibbous if it is more than 50. Cusp Angle is described more fully at <http://www.lunar-occultations.com/iota>.

Phone the IOTA occultation line, 301-474-4945, for updates and details, or check IOTA's Web site at <http://www.lunar-occultations.com/iota> David Dunham, [dunham@erols.com](mailto:dunham@erols.com), phone 301-474-4722

## Grazing Occultation of SAO 79005, 2000 April 10

A northern-limit graze of 7.7-mag. SAO 79005 will occur in a 1.2-mile-wide path shown below across the Maryland suburbs of Washington, D.C. The graze will occur between 9:58 and 10:02 pm EDT Monday evening, April 10. The graze will occur on the dark side of the 43% sunlit Moon near the north cusp. In a clear sky, the event should be visible with 4-inch or larger telescopes. We hope to arrange to observe the graze from the Univ. of MD golf course, meeting at the UMD Observatory (near the north edge of the graze zone) on the south side of Metzert Rd. at 8:15 pm. Let me know if you can join our expedition, and if you need any timing equipment. We will record WWV along with WTOP at 1500 AM so that broadcast can be recorded by others to time the graze. You might want to observe elsewhere in the path; if so, let me know so that observations can be coordinated. No occultation will occur north of the graze zone. South of the zone the dark-side disappearance of a short total occultation might occur as early as 9:52 pm. Updated information about the graze (weather go/no-go, observing sites) will be available at <http://iota.jhuapl.edu> or on the IOTA line at 301-474-4945. David Dunham, [dunham@erols.com](mailto:dunham@erols.com) or 301-474-4722.

*See the graze map on the following page.* 

*This is the last graze crossing the DC Metro Area until October.*

## Other National Capital Area Meetings, etc.

**U.S. Naval Observatory (USNO)** Mondays, April 3, 10, 17, and 24 7:30 PM - USNO public nights 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. Source: <http://www.usno.navy.mil>.

**Department of Terrestrial Magnetism (DTM) Carnegie Institute** — Wednesdays at 11:00 a.m. in the Seminar Room of the Main Building. Call (202) 686 4370 to confirm. No info for April available at press time. Source: <http://www.ciw.edu/DTM-seminars.html>

**Goddard Scientific Colloquium** — All seminars will be held in GSFC Building 3 Auditorium at 3:30 P.M. Contact Carol Krueger, at (301) 286-6878 to confirm. **April 7** William Seegar, US Army Aberdeen, "Space-Based Tracking of Bird Migrations"

**April 14** Frank Wilson, University of California, San Francisco, "Preternatural Pentadactyly in the Age of Planetary Probes: Can We Explore Mars Without Astronauts?"

**April 21** Kirpal Nandra, GSFC, "X-rays from Extragalactic Black Holes"

**April 28** Yoram Kaufman, GSFC, "Early Results from EOS Terra"

Source: <http://lheawww.gsfc.nasa.gov/users/djt/colloq/>

**Laboratory for Astronomy and Solar Physics (LASP)** — Seminars are on Thursday at 3:30 PM in GSFC Bldg. 21, Room 183A.

**April 6** Volker Bromm, Yale University, "Exploring the Physics of Primordial Star Formation"

**Monday, April 10** Felix Mirabel, Centre d'Eclides de Saclay, "Microquasars"

**April 13** James Kasting, Pennsylvania State University, "Habitable Zones around Stars and the Search for Life on Extrasolar Planets"

**April 20** Stacy McGaugh, University of Maryland, "Cosmological Constraints from Dark Matter Dominated Galaxies"

**April 27** Sally Heap, GSFC, "The Hell Gunn-Peterson Effect"

Source: [http://stars.gsfc.nasa.gov/www/lasp\\_colloq/index.html](http://stars.gsfc.nasa.gov/www/lasp_colloq/index.html)

**Laboratory for High Energy Astro-**

**physics (LHEA) Tuesday Seminar Series** — NASA GSFC Building 2, Ground Floor Conference Room, 3:30 P.M.

**April 4** Dr. Andrew Smith, U of Md., "Milagrito Data on Gamma-Ray Bursts"

**April 11** Dr. Sergei Nayakshin, NRC and LHEA/GSFC, "X-ray Reflection Spectra: How do Accretion Disk Theories Compare to Observations?"

**April 18** Dr. Anne Esin, Caltech, "Modeling X-ray and Optical Emission from Black Hole X-ray Binaries"

**April 25** TBD.

Source: <http://lheawww.gsfc.nasa.gov/docs/lhea/TuesSeminar/Seminar.html>

**LASP Stellar & Extra-Galactic Astronomy Lunch** — Talks are Wednesdays at 12:00 Noon in Room 242 of Building 21.

**April 5** Larry Nittler, GSFC (LEP), "Supernova Dust in Meteorites"

**April 12** Povilas Palunas, GSFC/CUA, "Structure at High Redshift"

**April 19** Al Kogut, GSFC, "DIMES: Diffuse Microwave Emission Survey"

<http://hires.gsfc.nasa.gov/~gardner/seal/>

**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 [www.pha.jhu.edu/facilities/observatory/telescope.html](http://www.pha.jhu.edu/facilities/observatory/telescope.html).

**Montgomery College's Planetarium**

Fenton St. in Takoma Park. **Saturday, April 22** at 7:00 P.M. "Black Holes, Gravity to the Max" 301-650-1463.

Source: <http://www.mc.cc.md.us/Departments/planet/>

**University of Maryland College Park Astronomy Department Colloquia**

No info for April available at press time. Source: <http://www.astro.umd.edu/colloquia/>

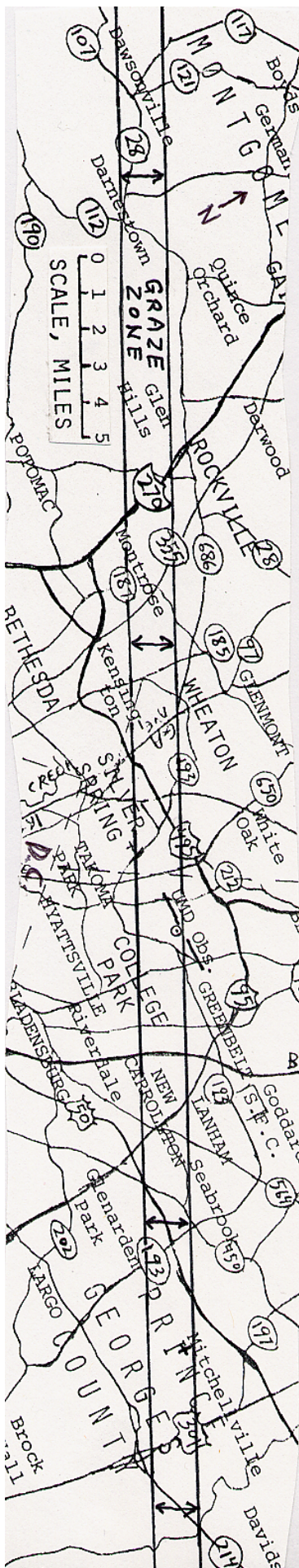
**Northern Virginia Astronomy Club**

(NOVAC) meets the second Sunday of each month at Lecture Hall 1 on the Fairfax campus of George Mason University. The Lecture Hall is next to Fenwick Library, on the North side of campus across Patriot Circle from the parking lots G and F. Parking in these lots is free on Sundays. Meetings start at 6:00 p.m.

Source: <http://astro.gmu.edu/~novac>

**University of Maryland Observatory** on Metzerott Road. Open house on 5 and 20

(Continued on page 7)



Map for SAO 079005 Graze on April 10

## Other National Capital Area Meetings, continued

(Continued from page 6)

of each month. Info: (301) 405-3001  
Source: <http://www.astro.umd.edu/openhouse/>

**Greenbelt Astronomy Club** meets on the last Thursday of each month (except holidays) at 7:30 p.m. at the Howard B. Owens Science Center, 9601 Greenbelt Road, Lanham, MD 20706. (Call the Science Center at 301-918-8750 or (301) 441-4605 to confirm meeting dates). Club meetings are open to the general public. Source: <http://www.gsfc.nasa.gov/docs/outreach/gac/GAC.html>

**National Air & Space Museum** – Free lectures at the Einstein Planetarium and other daily events. 202-357-1550, 202-357-1686, or 202-357-1505 (TTY)  
Source: <http://www.nasm.edu>.  
ASM Lecture Series on Exploring Earth's Moon

Following the 30th anniversary of the Apollo 11 and 12 Moon landings, the “Exploring Space Lecture Series 2000” is looking at the history of lunar exploration, what we learned about the Moon, and what we continue to learn. The three remaining lectures in this series at the Smithsonian’s National Air and Space Museum on the Mall are:

“Apollo and Lunar Evolution”, on Tuesday, April 25 at 7:30 PM, in the Langley IMAX Theater. From the unique perspective of the only geologist to walk on the Moon, Apollo 17 astronaut and former Senator Harrison H. Schmitt will describe theories of the Moon’s origin and the events that shaped the lunar surface.

“Lunar Samples and the Story of the Moon”, on Wednesday, May 24 at 7:30 PM, in the Einstein Planetarium. Graham Ryder, staff scientist at the Lunar and Planetary Institute in Houston, Texas, will discuss what the carefully preserved lunar samples still teach us about the Moon.

“Back to the Moon: The Lunar Prospector Mission”, on Wednesday, June 14 at 7:30 PM, in the Einstein Planetarium. Alan Binder, Principal Investigator for Lunar Prospector, offers a first-hand account of the mission: its goals and results, and what its findings mean for the future.

All lectures are free and no tickets or reservations are required. Lectures begin at 7:30 PM and doors open 15 minutes prior to the lecture. For more information, call 202-357-2700 or access the Museum’s Internet web site: [www.nasm.si.edu](http://www.nasm.si.edu).

Source: Leith Holloway

### NASA/GSFC LEP Seminar Laboratory for Extraterrestrial Physics Brown Bag Seminar

The Laboratory for Extraterrestrial Physics (LEP) at NASA’s Goddard Space Flight Center conducts weekly science seminars Fridays at noon in Room 8 in Building 2 at Goddard. Since the seminar is conducted during the lunch hour, the audience often brings their lunch.

April 7 TBD Dr. Tamas Gombosi, University of Michigan, Ann Arbor, Michigan, [tamas@umich.edu](mailto:tamas@umich.edu)

April 14 “The Magnetic Origins of Solar Eruptions”, Dr. Spiro Antiochos, NRL, Washington, D.C., [spiro@zeus.nrl.navy.mil](mailto:spiro@zeus.nrl.navy.mil)

April 21 “Latest Relativistic Electron Modeling using the Salamambo Code: The GEM Storms, and Comparison with GPS and GEO Data”, Dr. Reiner Friedel,

LANL, Los Alamos, New Mexico, [friedel@lanl.gov](mailto:friedel@lanl.gov)

April 28 TBD, Dr. Robert MacDowall, NASA/GSFC, Greenbelt, MD  
Source: [http://lepjas.gsfc.nasa.gov/~seminar/lep\\_seminar.html](http://lepjas.gsfc.nasa.gov/~seminar/lep_seminar.html)

### Washington Area Astronomers Meeting

No info for April available at press time. Contact Mary Ann Phillips at the University of Maryland, [maryann@astro.umd.edu](mailto:maryann@astro.umd.edu), (301) 405-1505.

Source: <http://aa.usno.navy.mil/waa/>

### Delmarva Stargaze

On April 6-9, there will be a star party/ astronomy meeting called the Delmarva Stargaze in Tuckahoe State Park on the Maryland Eastern Shore. I think this is less than 80 miles east of Washington, so it might be of interest to some in NCA, especially those in the eastern suburbs. More information is at their Web site, <http://www.delmarvastargazers.org>  
Source: David Dunham

## Meteor Showers April Radiants

Full Moon: April 18

### Major Activity

Radiant	Duration	Maximum
Lyrids (LYR)	April 16-25	April 21 at 22:12 UT

### Minor Activity

Radiant	Duration	Maximum
Tau Draconids	March 13-April 17	March 31-April 2
Librids	March 11-May 5	March 11-May 5
Delta Pavonids	March 21-April 8	April 5/6
Pi Puppids (PPU)	April 18-25	April 23/24
April Ursids	March 18-May 9	April 19/20
Alpha Virginids	March 10-May 6	April 7-18
April Virginids	April 1-16	April 7/8
Gamma Virginids	April 5-21	April 14/15

### Daylight Activity

Radiant	Duration	Maximum
April Piscids	April 8-29	April 7 20/21

Source: <http://comets.amsmeteors.org/meteors>

# Getting to the NCA Monthly Meeting

**Saturday, March 4**

**5:30 P.M. - Dinner** with the speaker and NCA members at the

Sushi Chalet  
4910 Fairmont Ave.  
Bethesda MD  
phone: 301-633

There is 2-hour metered parking on Fairmont Ave. (The meters are in use 9 A.M. – 10 P.M. except Sunday). The meters take nickels, dimes and quarters; 50¢ per hour.

**7:30 P.M. - NCA Meeting** at Lipsett Auditorium in Building 10 at NIH. Guest speaker: Dr. Judith Lean to Talk on the Role of the Sun in Global Change and Space Weather

## Directions to the Meeting Place

**From Rockville Pike (Wisconsin Ave., Rt. 355)**

To get to the parking lot at the South entrance (this will be the entrance for the next three years or so until they finish the new wing) from Rockville Pike, enter NIH at the Metro Entrance: South Drive (traffic light). Go straight ahead. At the third stop sign you will be at the parking lot, but you will have to make a left turn then a right to get to the entrance to the lot. Make a right turn into the lot.

**From Old Georgetown Rd.**, enter at Lincoln Drive (traffic light nearest to Suburban Hospital). Go straight ahead. The second stop sign is at a T. Bear left and the lot will be on the right. Make a right turn into the lot.

**Metrorail Riders** - From Medical Center Metro Station: Walk down the hill, past the bus stops. Continue straight past the anchor. At the second stop sign after the anchor, bear right up the incline into the entrance of Building 10, the tallest building on campus (walking time less than 10 minutes).

**Taking the J2 or J3 buses** from Silver Spring, get off at the Metro stop and follow the directions given for motorists from that point. If coming from Montgomery Mall, get off at the first stop in NIH, before the Clinical Center. There are signs near the ramp for the garage directing you into the side entrance. Walk straight through the building to the amphitheater.

## Directions to the Restaurant

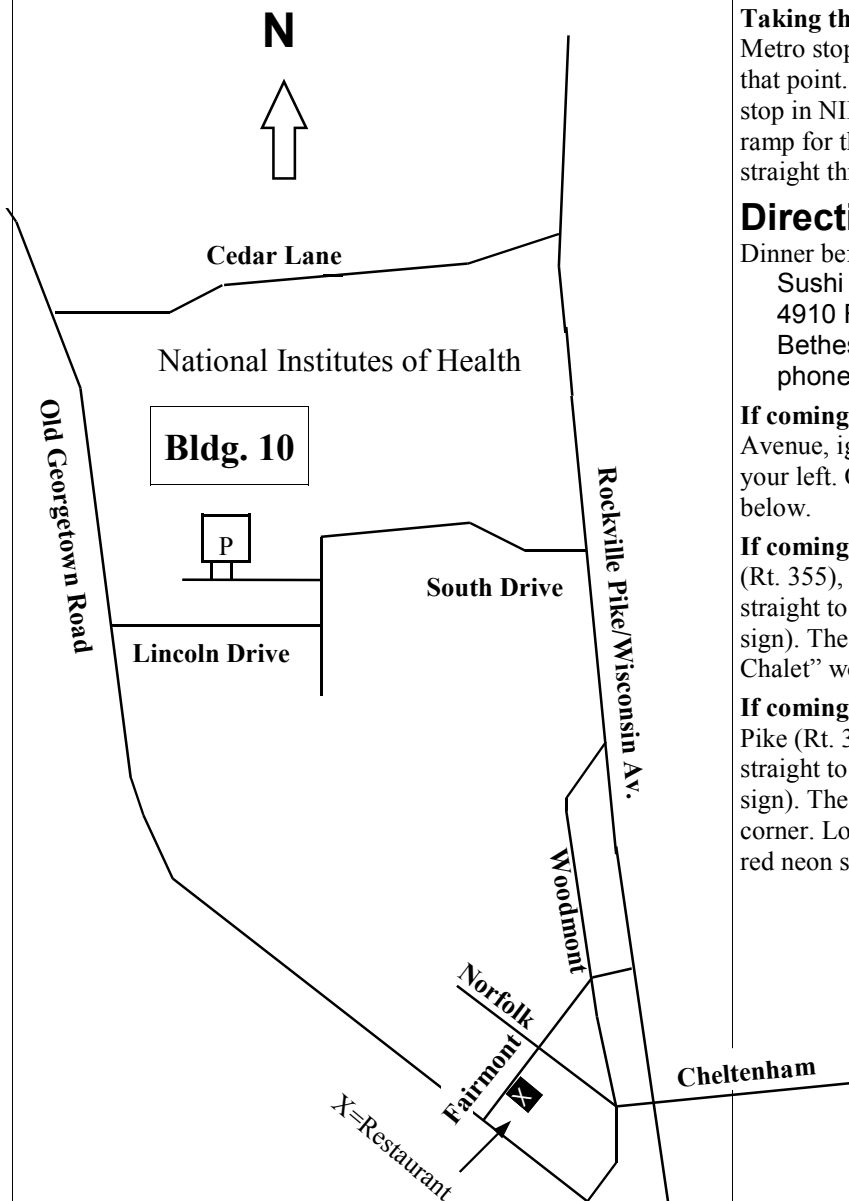
Dinner before the meeting will be at 5:30 P.M. at  
Sushi Chalet  
4910 Fairmont Ave.  
Bethesda MD  
phone: 301-633

**If coming from the District**, when going north on Wisconsin Avenue, ignore all signs until you pass Old Georgetown Road on your left. Once past Old Georgetown Rd., follow the directions below.

**If coming from south of Bethesda, go north on Wisconsin Ave.** (Rt. 355), turn left onto Cheltenham Dr. (traffic light). Go straight to go onto Norfolk Ave. Turn left at Fairmont Ave. (stop sign). The restaurant will be on your left. Look for the "Sushi Chalet" words on the awning and red neon sign of the restaurant.

**If coming from north of Bethesda, go south on the Rockville Pike** (Rt. 355). Turn right onto Cheltenham Dr. (traffic light). Go straight to go onto Norfolk Ave. Turn left at Fairmont Ave. (stop sign). The restaurant will be on your left, a few doors from the corner. Look for the "Sushi Chalet" words on the awning and the red neon sign of the restaurant.

**After dinner**, retrace your path to Wisconsin Ave. (Rt. 355). Make a left turn to go north on Wisconsin Ave./Rockville Pike/Rt. 355. and follow "directions to the meeting place" at the top of this page.





## National Capital Astronomers, Inc.

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Harold Williams, NCA Webmaster, hwilliam@mc.cc.md.us, 301-650-1463 planetarium, 301-565-3709 home.

Leith Holloway, NCA contact for Junior members, jleithh@aol.com, 301-564-6061, please no calls during 6-8 pm.

Elliott Fein, NCA Star Dust Editor, elliot.fein@erols.com, 301-762-6261 home.

NCA Web Page: <http://capitalastronomers.org/>

### SERVING SCIENCE & SOCIETY SINCE 1937

NCA is a nonprofit, membership-supported, volunteer-run, public-service corporation dedicated to advancing astronomy, space technology, 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 in a number of capacities. Many members serve as teachers, clinicians, and science fair judges. Some members observe total or graze occultations of stars occulted by the Moon or asteroids. Most of these NCA members are also members of the International Occultation Timing Association (IOTA).

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

**Consumer Clinics:** Some members serve as clinicians and provide advice for the selection, use, and care of binoculars and telescopes and their accessories. One such clinic is the semiannual event held at the Smithsonian Institution National Air and Space Museum.

**Fighting Light Pollution:** NCA is concerned about light pollution and is interested in the technology for reducing or eliminating it. To that purpose, NCA is an Organization Member of the International Dark

Sky Association (IDA). Some NCA members are also individual members of IDA.

**Classes:** Some NCA members are available for educational programs for schools and other organizations. The instruction settings include star parties, classroom instruction, and schoolteacher training programs that provide techniques for teaching astronomy. NCA sponsors a telescope-making class, which is described in the *Star Dust* "Calendar of Monthly Events".

**Tours:** On several occasions, NCA has sponsored tours of astronomical interest, mainly to observatories (such as the National Radio Astronomy Observatory) and to the solar eclipses of 1998 and 1999.

**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 astronomy, space technology, and related sciences through discounted memberships, mentoring from dedicated members, and NCA's annual Science Fair Awards.

**Fine Quality Telescopes** up to 36-cm (14-inch) aperture are available free for members' 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)

\_\_\_\_\_  
First name(s)

\_\_\_\_\_  
Last name

(\_\_\_\_\_) \_\_\_\_\_  
Telephone

\_\_\_\_\_  
E-mail

\_\_\_\_\_  
Street or Box

\_\_\_\_\_  
Apartment

\_\_\_\_\_  
City

\_\_\_\_\_  
State

\_\_\_\_\_  
Zip Code + 4

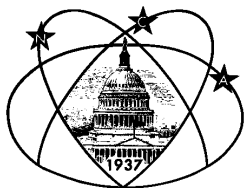
If this is for a family membership, please list the names of the additional participating immediate family members in same household with birth dates of all those under 18 years old: \_\_\_\_\_

**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!**



## National Capital Astronomers, Inc.

If Undeliverable, Return to  
NCA c/o Nancy Roman  
4620 N. Park Ave., #306W  
Chevy Chase, MD 20815-4551

**FIRST CLASS**

**DATED MATERIAL**

### **Inside this issue:**

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*Star Dust* is published ten times yearly, September through June, by the National Capital Astronomers, Inc. (NCA), serving science & society since 1937.

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