Star Dust

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Stars in the Laboratory: Presolar Grains in Meteorites

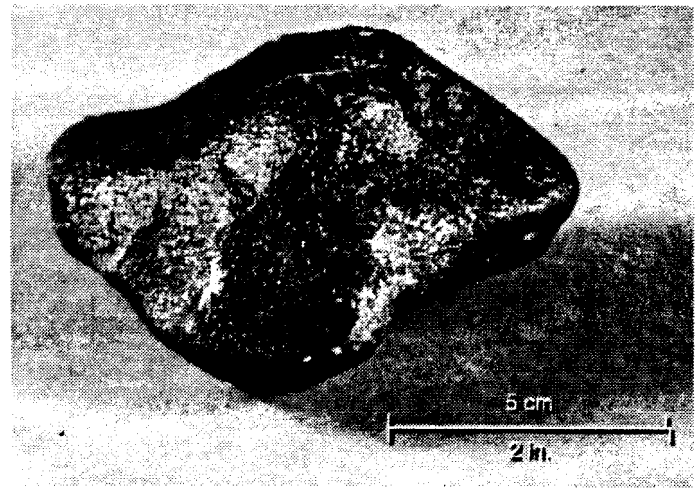
by Larry R. Nittler

The next meeting of the National Capital Astronomers will be held on Saturday, December 6 at 7:30 P.M., in the Lippsett Auditorium on the main floor of the Clinical Center (Building 10) at the National Institutes of Health (NIH). Larry R. Nittler of the Carnegie Institution of Washington, Department of Terrestrial Magnetism will speak on "Stars in the Laboratory: Presolar Grains in Meteorites." The speaker sent the following abstract and biography:

Primitive meteorites contain grains of "stardust." These tiny specks of dust formed in the winds of ancient stars on in supernova explosions and became part of the cloud from which the Sun and planets formed. The chemical and isotopic compositions of these grains reflect those of their stellar sources. They thus serve as probes of the physical conditions inside stars and in supernova ejecta. Presolar grains identified so far include SiC, diamond, graphite, silicon nitride, Al_2O_3, and $MgAl_2O_4$. This talk will discuss how these grains are isolated from meteorites and analyzed in the laboratory, and how they provide information about stellar and galactic evolution, stellar nucleosynthesis of the elements and processes in interstellar space and the early Solar System.

Larry Nittler received a B.A. in physics from Cornell University in 1991 and a Ph.D., also in physics at Washington University in St. Louis in 1996. Since then, he continued his studies of presolar grains in meteorites via a postdoctoral fellowship at the Carnegie Institution. In jest, Larry Nittler refers to himself as "Interstellar Dust Buster and Mushroom Chief." ❍

STScI-PRC95-20BA PIECE OF THE ASTEROID VESTA



This meteorite is a sample of the crust of the asteroid Vesta, which is only the third solar system object beyond Earth where scientists have a laboratory sample (the other extraterrestrial samples are from Mars and the Moon). The meteorite is unique because it is made almost entirely of the mineral pyroxene, common in lava flows. The meteorite's mineral grain structure also indicates it was once molten, and its oxygen isotopes are unlike oxygen isotopes found for all other rocks of the Earth and Moon. The meteorite's chemical identity points to the asteroid Vesta because it has the same unique spectral signature of the mineral pyroxene. The meteorite also has the same pyroxene signature as other small asteroids, recently discovered near Vesta, that are considered "chips" blasted off Vesta's surface. This debris extends all the way to an "escape hatch" region in the asteroid belt called the Kirkwood gap. This region is swept free of asteroids because Jupiter's gravitational pull removes material from the main belt and hurls it onto a new orbit that crosses Earth's path around the Sun. The meteorite probably followed this route to Earth. It was torn off Vesta's surface as part of a larger fragment. Subsequent collisions broke apart the parent fragment and threw pieces toward the Kirkwood gap and

***VESTA Caption,** Continued on page 3*

Calendar of Monthly Events

The Public is Welcome!

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

Mondays, December 1, 8, 15, 22, and 29, 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.

Tuesdays, December 2, 9, 16, 23, and 30, 7:30 PM-Telescope making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 202/362-8872.

Saturday, December 6, 5:30 PM-Dinner with the speaker and other NCA members at the North China Restaurant on Old Georgetowm Pike, Bethesda, MD. *See* map and directions on back page.

Saturday, December 6, 7:30 PM-NCA meeting, will feature Larry R. Nittler, Department of Terrestrial Magnetism, Carnegie Institution, speaking on "Stars in the Laboratory: Presolar Grains in Meteorites." For directions, *see* map and directions on back page.

Fridays, December 5, 12, 19, and 26, 7:30 PM-Telescope making classes at American University, McKinley Hall Basement. Information: Jerry Schnall, 202/362-8872.

Fridays, December 5, 19, and 26, 8:30 PM-Open nights with NCA's Celestron–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.

During questionable weather, call the IOTA Hotline (Phone: 301/474-4945) for NCA meeting status. The absence of a cancellation notice on the Hotline means the meeting will take place.

See page 8 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 1997*, the *Observer's Handbook 1997*, in numerous software packages, and other links available on the NCA Home Page (*see* above for address). NCA members can purchase all these (and much more) at a discount. To join NCA, use membership application on page 9.

Volunteers Needed For The Astroscout Program

The National Park Service is looking for volunteers who are willing to assist with an astronomy program called "Astroscout." The National Park Service at the Rock Creek Park Nature Center and Planetarium is offering to Boy Scouts a free, exciting new program to learn about astronomy. A multimedia introduction to the night sky, this program consists of a planetarium show, a video, instruction in astronomy, and a viewing of the night sky through telescopes. Interested Boy Scouts will be able to start the Astronomy Merit Badge at this event.

Volunteers with telescopes are needed from 5:45 PM to 7:15 PM on Saturday, December 13 1997 to bring their telescopes to Military Field at the corner of Military and Glover Roads for the scouts to view the stars and other interesting phenomena.

The Rock Creek Nature Center and Planetarium is located in Rock Creek Park at 5200 Glover Road NW, Washington DC 20015. If you have any questions or would like to volunteer, please call Ranger Blaine Eckberg at (202) 426-6829. ○

More Volunteers Needed

Bishop Claggett Center in Buckeystown, Maryland, needs volunteers to lead astronomy workshops for middle school students and their families on December 29-31. If you can volunteer on any one of these days, please contact Donna Kerner, Director, Youth Programs via e-mail at bishclag@erols.com.

The Next Generation Space Telescope

by Wayne H. Warren Jr.

At the October 4, 1997 monthly meeting, NCA members and guests were pleased to hear a lecture entitled "Seeing the First Objects with the Next Generation Space Telescope" given by Dr. John C. Mather of the Laboratory for Astronomy and Solar Physics, NASA Goddard Space Flight Center. Dr. Mather is well-known to longtime NCA members, having given us a lecture about the COsmic Background Explorer (COBE) on December 4, 1982. Shorter-term members may be familiar with his COBE work as well through the many articles and scientific papers that he has published on the subject. Having been outstandingly successful with the COBE project, Dr. Mather has been entrusted with the initial responsibilities for NASA's most "visible" project to fly in the first decade of the new millennium.

Dr. Mather began by reminding us that there are many things that astronomers (and many other people as well) would like to know about the Universe and still don't. Over the last decade or so, we have made tremendous progress in our quest for astronomical and astrophysical knowledge. Sophisticated ground-based telescopes and by space missions such as NASA's COBE, Hubble Space Telescope (HST), Compton Gamma-Ray Observatory (CGRO), International Ultraviolet Explorer (IUE), and Rossi X-Ray Timing Explorer (RXTE), plus ESA's HIgh Precision PARallax Observing Satellite (HIPPARCOS), have contributed to our knowledge. But as much as we learn, there are still many things about which we remain rather ignorant, and new knowledge often leads to more questions.

Our current understanding, although there are alternative views, is that the Universe began (or began again) with the so-called "Big Bang" about 13 billion years ago (also written 13×10^9 years or 13 Ga). As the Universe expanded and cooled, the original opaque plasma became transparent at about age 3×10^5 years. As we look outward toward the edge, as we did using the COBE satellite, we see structure that we interpret as ripples in the space-time continuum. The COBE map of the gravitational field shows an anisotropy of about 1 part in 10^5. We are uncertain about how critical this anisotropy is and whether or not the Universe would have evolved in the same way if completely isotropic or if anisotropic to a differing degree. There is evidence that the clumpiness caused matter to eventually combine to form galaxies.

The Universe continued to expand for perhaps 100 Ma before the first galaxies began to form. The period that followed, between the formation of the first galaxies and essentially what we see today when we look back with HST to about 40 percent to the edge, is what we call the dark age, about which we know practically nothing. We do not know why galaxies formed, when or how they formed, or very much about how they evolved. We don't really know what triggered first generation star formation, although we have lots of evidence and some understanding of the star formation process. We believe that between 90 and 99 percent of all matter in the Universe is invisible to us (the so-called "dark matter"), as determined from the rotation curves of galaxies by the pioneering work of NCA member Vera Rubin. We have pretty good ideas about the life cycles of stars, at least that they form primarily in spiral arms of galaxies, they evolve through different regions of the Hertzsprung-Russell (H-R) diagram according to their changing physical conditions, until they run out of nuclear fuel and contract to white dwarfs (as will the Sun) or explode as supernovae to become burned out neutron stars or black holes. The material ejected during these phenomena eventually condenses to form the next generation of stars, enriched with heavy elements synthesized during the explosive stages of the previous generation. This same material condenses to form planets, asteroids, comets, etc., which

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Astronomical Calendars for 1998

I am again volunteering to place a bulk order for Guy Ottewell's Astronomical Calendar, but the procedure will be slightly different this year because it took 3-4 months before I was able to deliver the orders last year and a few people even had to make special trips to my house, as I did theirs. The discount is substantial for orders of four or more, viz. the regular price is \$19.95 + \$3. (S&H) = \$22.95 each, while the discount price is \$15.96 + \$4. (total). To keep things simple, I will collect \$17.00 for each copy at the December NCA meeting, so please bring payment with you. If we have fewer than four orders, there will be no discount and I will withdraw from service, in which case we can order individually. If we have considerably more than four orders, I will refund according to the final cost.

Wayne Warren

***VESTA Caption**, Continued from page 1*

onto a collision course toward Earth. The fragment's journey ended in 1960 when it fell in Western Australia. NASA's Hubble Space Telescope observations further confirm this scenario by revealing a giant impact basin on the 325-mile (525 km) diameter asteroid. The ancient impact was so powerful, it tore off a piece of the asteroid's crust, exposing a deeper mantle of rock. Most of the identified meteorites from Vesta are in the care of the Western Australian Museum. This 1.4 pound (631 gm) specimen comes from the New England Meteoritical Services. It is a complete specimen measuring 3.7 inch x 3.1 inch x 3.4 inch (9.6 cm x 8.1 cm x 8.7 cm) showing the fusion crust, evidence of the last stage in its journey to Earth. Photo Credit: R. Kempton (New England Meteoritical Services)

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.

eventually yield such things as rocks, minerals, organic chemicals and, in the case of the Solar System, such things as we like to think of as intelligent beings who can study these phenomena. One thing that we can be sure of is that virtually all of the materials that we encounter every day originated in some supernova explosion that occurred somewhere in the Milky Way more than 5 Ga ago.

We'd really like to know more about the details of this evolutionary process, especially about the end processes that result in the highly condensed objects mentioned above. Do black holes disintegrate? Is interstellar space littered with the burned out cinders of black dwarfs and neutron stars? What fraction of dark matter do these cinders represent? What about the large-scale structure of the Universe? What is its actual shape, if such a thing can even be defined? The Universe is expanding, but what is it expanding into? Is space being created at the edge? We hope to be able to answer at least some of these profound questions with the next generation of space-borne missions that will be flown by NASA, ESA, and possibly other space agencies around the world.

NGST And Other Planned Missions

Dr. Mather briefly describe some of the planned NASA missions. The NGST will be designed to study the dark region mentioned earlier. It will tentatively be launched in 2007. There is a Space Interferometry Mission (SIM), scheduled for launch in 2005, primarily designed to detect extrasolar planets. The mission's extremely high resolution will afford us the opportunity to measure the distances of stars on the other side of the Galaxy to ±10% accuracy. We might think of this mission as the successor to HIPPARCOS, although the Europeans have another astrometric mission on the drawing board for the 2000-2002 time frame. Farther down the line, perhaps in the 2012-2020 time frame, depending on how soon we can figure out how to do it, would be a mission to take spectra of extrasolar planets to detect the presence of gaseous atmospheric constituents such a methane, CO_2, water vapor, etc. This might eventually be followed by extrasolar planetary weather mapping if such a thing is ever possible, but that would almost certainly be at least several generations away.

Dr. Mather delved more deeply into what the NGST should be able to accomplish. As mentioned earlier, NGST will study the dark period when galaxies and their constituent stars first formed. It will also attempt to determine the "shape" of the Universe by measuring the curvature of space, which requires the determination of distances to extremely remote objects using, for example, supernovae as standard candles. Late stages of stellar evolution will be studied, as well as early stages near the bottom of the main sequence, where low-mass objects sometimes become stars and sometimes end up as brown dwarfs, depending on their masses. Closer to home, the NGST will attempt to directly observe objects in the Kuiper Belt, which is a zone between the orbits of Uranus and Neptune that is thought to be the origin of certain classes of comets.

Another important objective is to extend NGST's sensitivity far enough into the infrared (IR) to detect emission from objects at room temperature. This is approximately 300 kelvins (K), for which the emission peaks at 10000 nanometers (nm), as compared with stellar temperatures of 3000 K (peaking at 700 nm) for red (M-type) stars to 30000 K (200 nm) for very hot (O-type) blue stars. The detection of such cool objects is tricky, however, because everything in the detecting structure must be kept cold enough so as to not emit IR radiation itself. Of course, such techniques have been developed for missions such as NASA's Infrared Astronomical Satellite (IRAS) and the currently operating ESA Infrared Space Observatory (ISO), so there shouldn't be major problems in that area.

Dr. Mather explained more about why we want to build the NGST. First of all, why do we need a larger telescope in space, where the cost is so much higher? As we've seen by comparing images from the HST with what we have traditionally been able to do from the ground using much larger telescopes, there are many problems with observing through the atmosphere. Even though adaptive optics techniques are greatly improving atmospheric "seeing" problems, the situation is still far superior in space, where resolution is limited only by the optical quality of the telescope and diffraction effects. At longer wavelengths, atmospheric effects are somewhat reduced on the ground, but emission by hydroxyl radicals, atmospheric water, and other constituents, either severely limits or entirely blocks extraterrestrial radiation. Clearly, a space-borne instrument is not constrained by all these problems, plus it is easy to keep the structure cold by merely shielding it from direct sunlight.

Among the important scientific questions to be studied by the NGST is how galaxies form and evolve. Dr. Mather showed the classic tuning fork diagram that Hubble devised in his attempt to classify galaxies. This shows the various types of spirals, as classified by the tightness, numbers of arms, and the presence or absence of a "bar" along the major axis. It also shows different kinds of ellipticals from the essentially round to the very oblong. We once thought that spirals somehow naturally evolved to ellipticals, because the latter seemed to contain less dust and older stars. Our picture of this process has changed dramatically over the last 20 years with the realization that galactic merger events are rather common. As discussed by Dr. François Schweizer at the February 5, 1994 NCA meeting, merger events not only produce many of the irregularly shaped and peculiar galaxy forms, but may also produce elliptical galaxies as their end products. We should be able to learn about the formation of galaxies if we can look back far enough to see their initial formation. The Hubble deep field image shows galaxies having redshifts up to about 5, which is not nearly back far enough (look-back time 5 Ga) to reach the formation era. NGST should be able to see to a redshift of 10-13, corresponding to look-back times of 11-12 Ga. The observation of objects with such large redshifts is, of course, a major reason that the NGST must be sensitive in the near-IR region where the HST becomes less sensitive.

Another important topic to be studied by the NGST is the early stages of

star formation. HST images of star forming regions like the ones in Orion show what appears to be gas flow around small opaque objects (globules) inside which stars may be forming. It is hoped that the NGST, with its IR sensitivity, will be able to penetrate many of these clouds to reveal the protostars inside. Images of the Horsehead Nebula region in the visible and IR show clearly that the latter do penetrate the cloud to show internal activity.

As these protostars age, they develop disks of dust that we think eventually condense into planetary bodies. HST images shown by Dr. Mather reveal such disks around stars like β Pictoris. The amount of material in this system indicates that protoplanetary collisions have occurred. (We heard a lot about the β Pictoris phenomenon from Dr. Carol Grady at our November 2, 1994 NCA meeting.) NGST should allow us to see closer to these stars and to perhaps reveal additional details about the nature of their debris. Dr. Mather showed quite a few HST images of protostellar disks in Orion and of regions of star formation in other nebulae.

Dr. Mather next turned his attention to the dark matter problem mentioned earlier. He showed an image of a distant cluster of galaxies in which gravitationally lensed arcs of more distant galaxies can be seen. Since the degree of lensing depends on the total mass of the lensing "object", in this case the foreground cluster of galaxies, the total mass can be estimated. An estimate of the mass of the luminous matter can be made by classifying each galaxy in the cluster, assigning a typical mass for that type of galaxy, then summing over all galaxies.

Although these estimates may be a bit rough, a comparison of the two masses gives one result that leads us to believe that the ratio of dark to luminous matter is roughly 10 to 1. Essentially the same results are found from the rotation curves of individual galaxies. While rotation curves have only been determined for relatively nearby galaxies to date, the NGST should be able to extend this work to much greater distances.

NGST Requirements

The decision to build the NGST resulted from recommendations made by a committee formed by NASA several years ago to study the various options for future space astronomy missions. This committee, consisting mostly of non NASA scientists, made a three-part recommendation: (1) Continue to operate the HST as an ultraviolet-and visible-wavelength facility; (2) develop capabilities for space interferometry, which uses multiple telescopes to construct images having resolutions comparable to a single instrument of size equal to the separation of the interferometer, and; (3) develop a successor to the HST that is IR-sensitive and considerably larger in aperture. As a result of recommendation 3, NASA Headquarters invited GSFC in October of 1995 to propose how this might be done and subsequently provided some funding to carry out a feasibility study resulting in specific recommendations. The detector system should be sensitive in the IR to see through dust and to observe the most distant galaxies. The extremely high optical quality originally specified for the HST is not required in the IR if we optimize for observations at 2 micrometers (υm), and this results in substantial cost savings. The telescope aperture was initially to be at least 4 meters, as determined primarily by weight considerations and launch capabilities. However, subsequent calculations showed that at least 8 meters would be required to do the desired science, so new ways must be developed to place the NGST into orbit.

In addition to the launch problem, consideration of where to place the NGST is important. Although the HST is in low Earth orbit, which makes periodic visits possible, there are many problems associated with a 90-minute orbit, such as Earth eclipses, orbit degeneration, the difficulty of making longer observations, etc. For these reasons, it is recommended that the NGST be put into a more distant location. One possibility is, of course, a geosynchronous orbit, but there are several others. An excellent possibility is the L2 Lagrangian point, which is located about 1.5 million kilometers outward from Earth away from the Sun. This point is actually easier to reach than the geosynchronous orbit. Another possibility is to launch away from Earth and let the satellite slowly move into a solar orbit at the same distance, but perhaps 60 degrees or so behind the Earth. A more ambitious possibility is to place the NGST farther away from the Sun, perhaps outside the asteroid belt, maybe even outside the plane of the Solar System to escape from most of the interplanetary dust that interferes with observations, especially in the IR.

Possible Designs

Keeping the telescope cold in space is not a serious problem because it is only necessary to shield it from the Sun with a sun shade. We then saw illustrations of several telescope and sunshade designs. The most important factor is probably to find a way to make an 8-meter telescope objective light enough to launch with a low-cost rocket, which is necessary to keep the mission cost under control. The rather flexible tolerances in the mirror figure make it possible to use novel techniques to make a thin mirror, and University of Arizona mirror expert Roger Angel has already made a thin mirror of sufficient accuracy. The thin glass is supported by a large number of adjusting screws that are controlled by picomotors, which are devices controlled by piezoelectric drivers. The real trick is to build such a mirror in pieces and assemble it in space to reproduce the required figure. It is assumed that thousands of adjustments would be necessary, so those capabilities must be built into the system. Obviously, there are many problems to be worked out, but with the technology improvements bound to occur over the next decade, along with recent advances in telescope and instrument making, it should be possible to construct the necessary equipment.

Current plans for the instrument cluster include four detector systems. The central instrument is an infrared camera with a 2 arcminute field of view. A longer wavelength camera and three-dimensional spectrometer capable of taking spectra of hundreds of galaxies simultaneously would be located around the perimeter of the focal plane.

NGST Vs. HST

Dr. Mather ended his talk by comparing ideas for the NGST with what was done

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TELESCOPE, Continued from page 5

for the HST about 25 years earlier. The new observatory will be larger but considerably lighter (about one quarter the weight). Adjustable optics will be used, which should avoid the kind of disaster that took place with the HST primary mirror. The greater distance from Earth means that longer observations will be possible with simple techniques, although the observatory will not be serviceable except remotely. All the techniques needed for the construction of the NGST are not yet fully developed, but we have learned many things along the way and believe that the project is technologically feasible.

There is little doubt that, with the capabilities described for the NGST by Dr. Mather, we would learn a lot about some of the most perplexing outstanding problems in astronomy and astrophysics. Along with the other missions planned for the first few decades of the next century, there should be much excitement and gratification for those of us who crave more understanding of the Universe in which we live.

The NCA is indebted to John Mather for giving this fascinating insight into what we can expect from space astronomy over the next few decades. I thank John for reviewing this "review" prior to publication. ○

Naked-eye Occultation Saturday Evening, Dec. 6th; Other Northeast U.S. Events

by David Dunham

If it is clear early Saturday evening, December 6th, bring a camcorder or binoculars to the NCA meeting. Just before it begins, at 7:29 pm, the 3.7-magnitude red star λ Aquarii will disappear behind the dark edge of the first quarter Moon, which will be 39 degrees above the southwestern horizon. Weather permitting, we will observe the occultation from the parking lot northwest of the Building 10 entrance. If conditions are good, the event might even be seen without optical aid. But binoculars are recommended for a good view. We will have a WWV time signal receiver. Recording that and the occultation with a camcorder can time the event to 0.03 second, which defines the star's position relative to the Moon's limb to about 30 meters accuracy, better than the Clementine spacecraft lunar laser altimeter measurements. These observations are valuable for defining the lunar profile, information needed to properly analyze solar eclipse observations to determine climatically significant solar radius variations. Even if you can't come to the meeting, wherever you are, it would be valuable if you can take a few moments to step outside and tape the occultation with a camcorder. See pages 94 and 96 of the July issue of *Sky and Telescope* for accurately timing the occultation with a camcorder even if you don't have a WWV receiver. But we will use CNN Headline News rather than The Weather Channel for the TV time reference station. If you have neither WWV nor cable, call the U.S. Naval Observatory master clock at 900-410-8463; the call should be placed via AT&T to ensure use of land lines, which will give an accuracy of a couple of hundredths of a second. If the call is not made via AT&T, or if the National Bureau of Standards' WWV 303-area-code number is used, the call might (or might not, you would not know) be routed through a geosynchronous satellite, causing a quarter-second delay, which is unacceptable. In the Washington, DC area, the USNO master clock can be reached with a local call to 202/762-1401, but those outside of the DC toll-free area should not use that number, because it might go through a satellite. Record the time just before and after the occultation (maybe even during it with a portable phone). Next week, a view of the Moon showing where λ Aquarii will disappear at several North American cities will be placed on our Web site given at the end of this notice, but it is not needed to observe the event. The star is so bright that, even with a telescope, a low power can be used so that the whole dark side of the Moon can be viewed, and the star simply followed up to the edge of the Moon to the disappearance. More useful on the Web site is a list of the predicted Universal Times for about 200 North American cities.

There are several other occultations that can be taped with a camcorder pointed into the eyepiece of a telescope; predictions for them are given below. The events marked with * can probably be recorded directly with a camcorder without a telescope, if your camcorder is 12x or higher, but the Aldebaran disappearance will be hard without a scope since the bright part of the nearly full Moon will be very close. The events marked with ? might be recorded directly if conditions are good. When aiming a camcorder into an eyepiece for events relatively far from the sunlit part of the Moon, first focus on the sunlit part of the Moon with autofocus, then switch to manual focus as you move the view towards the star. The Hyades disappearances that precede Aldebaran's disappearance on Friday evening, Dec. 12, will be easy just using autofocus since those events will all occur close to the terminator, providing a good reference for the autofocus. See IOTA's Web page at http://www.sky.net/~robinson/iotandx.htm for more information. The predictions on the next page were computed for Greenbelt, Maryland, about 12 miles northeast of downtown Washington, DC, but the times will usually be good to within a minute within 40 miles of Greenbelt, with the occultation usually occurring earlier in the western suburbs. For more accuracy or more distant locations, the A and B factors can be used, as described in the explanation of the predictions given at the end. Also, predictions for other locations will be supplied upon request by e-mail at dunham@erols.com for observers who will try to time many of these events. ○

Roving and Revolving Over the Red Planet

The review for the November meeting was not available at press time. It will be published in the next Newsletter.

I.O.T.A. Total Occultation Predictions For 1997 December for Greenbelt, Maryland, Longitude W 76d 52′ 09.9″, Latitude +38d 59′ 10.1″, Height +53 meters

DAY	E.S.T.			P	Z.C.	VIS	SP	PCT	SN	MN	MN	CUSP	WA	A	B	Star
	H	M	S		NO.	MAG		SNLT	AL	AL	AZ	ANG		M/O	M/O	Name
6	19	29	29	D*	3353	3.7	M0	47+		39	210	59S	122	–2.1	–1.0	λ Aquarii
6	20	45	22	D	3360	6.3	K0	48+		30	230	88S	93	–1.2	–0.3	78 Aquarii
7	20	17	26	D	3505	5.6	K0	59+		43	212	60N	61	–1.1	+1.3	20 Piscium
10	17	41	58	D	368	6.3	K0	88+	–11	34	106	30S	146	–1.8	–0.3	
12	19	55	29	D	667	5.3	G5	98+		42	104	77N	57	–0.7	+2.3	75 Tauri
12	20	04	12	D	672	6.6	F8	99+		44	106	52S	107	–1.4	+0.8	
12	21	00	03	D	677	4.8	A5	99+		54	119	35S	124	–2.1	–0.2	
12	21	15	14	D	680	6.7	F2	99+		56	124	16S	144	–2.7	–2.0	
12	22	59	57	D	685	6.5	F0	99+		67	172	15S	143	–2.7	–3.0	
13	00	16	38	D*	692	0.8	K5	99+		64	215	37S	120	–2.1	–1.5	Aldebaran
13	01	26	26	R	692	0.8	K5	99+		54	241	–84S	241	–1.7	+0.8	Aldebaran
19	04	59	46	R	1486	4.6	K2	73–		60	198	43N	317	–1.0	–3.3	31 Leonis
20	06	18	18	R	1589	5.7	M2	64–	–12	53	211	90N	269	–1.9	–1.4	56 Leonis
21	00	26	51	R	1678	5.8	F5	56–		11	95	11S	190	–0.4	+7.4	89 Leonis
22	00	57	16	R?	1772	3.9	A0	47–		6	96	46S	225	–0.3	+2.3	ε Virginis
24	02	49	32	R	1994	6.5	F8	28–		6	106	41N	320	+0.1	–1.6	
26	04	49	32	R*	2223	4.0	K0	12–		7	115	83N	283	–0.4	+0.4	γ Librae

The columns in the IOTA table above are defined as follows: **DAY E.S.T. (H M S)** gives day of month and hours, minutes, seconds of the predicted Eastern Standard Time of the occultation event. **P** is phenomenon: **D** for disappearance, **R** for reappearance. **Z.C. NO.** is the star's number in Robertson's Zodiacal Catalog. **VIS MAG** is the visual magnitude of the star. **SP** is the spectral type of the star. **PCT SNLT** is the percent of the Moon's disk sunlit (100% = Full Moon), followed by + for waxing, – for waning. **SN AL** is the altitude of the Sun above the horizon, given only when it is greater than or equal to –12. All angles are in degrees. **MN AL** is the altitude of the Moon above the horizon. **MN AZ** is the azimuth of the Moon, measured along the horizon eastward from the north point. **CUSP ANG** is the cusp angle of the event. This is the angle from the nearest lunar cusp to the star. The nearest cusp is identified by letter as the north (N) or south (S) cusp. Cusp angle is positive on the dark limb and negative on the bright limb. **WA** is the Watts angle of the event, measured at the center of the Moon's disk from the Moon's north rotation pole eastward to the star. It can be used with a lunar map to estimate the point of reappearance of a star relative to lunar features; a W.A. of 270 is near the lunar equator, 180 is near the south pole, and 360 is near the north pole. Events near WA 290 are conveniently close to Mare Crisium. **A B (M/O M/O)** are the rates of change of the predicted occultation time with changes in the observer's longitude and latitude, respectively. The units are minutes of time per degree of west longitude or north latitude (M/O).

Grazing Occultations, 1997 December

DATE	Day	EST	Star	Mag	%	alt	CA	Location
Dec 2	Tue	17:12	ZC 2773	6.0	8+	20	–1S	Myersville, MD (S-5) & Logansvil.,PA, -6
Dec 5	Fri	18:17	ZC 3211	8.0	35+	36	4S	Olney, Clarksv., & BelAir, MD (Sun-17dg)

Asteroidal Appulses, 1997 December

DATE	Day	EST	Star	Mag	Asteroid	dmag	dur. s	ap. in.	Location
Dec 1	Mon	19:41	PPM 183823	9.4	Neoptolemus	7.9	8	4	Virginia
Dec 3	Wed	17:58	SAO 189113	9.0	Herculina	2.8	6	4	e. Carolinas
Dec 4	Thu	7:06	SAO 134036	6.0	Artemis	7.1	11	1	Wisconsin
Dec14	Sun	5:03	PPM 195501	9.5	Hilda	4.8	7	5	Mexico
Dec27	Sat	1:45	44 Eridani	5.5	Nipponia	7.5	4	1	Georgia

See the October *Stardust* for the column definitions used in the grazing and appulses tables above.

Phone the IOTA occultation line, 301-474-4945, for updates and details; also, meeting places and maps for grazing occultations are often given on IOTA's Web site at http://www.sky.net/~robinson/iotandx.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

Other Planetariums, Observatories, and Science Centers in the Area

Montgomery College Planetarium —"Day of the Sun's Return, the Winter Solstice" Takoma Park, MD. December 20. (*See* their web site at http://myhouse.com/mc/planet.htm.)

Campus Observatory Open House — "Magnetic Storms on the Earth and Other Planets", speaker: Dennis Papadopoulos. Department of Astronomy, University of Maryland, College Park, MD. December 5, 8:00 PM.

"Topic to be announced.", speaker: Dr. Pat Harrington. Department of Astronomy, University of Maryland, College Park, MD. December 20, 8:00 PM.

National Museum of Natural History —"After the Planets Formed", speaker: Mereoriticist Dr. Timothy McCoy describes the process that shaped asteroids and planets transforming them from rocks to worlds. December 5, 12 Noon. Baird Auditorium, Free to the public.

National Air and Space Museum —"Together in Space", speaker: Rob Landis from Goddard Space Flight Center will present a historical overview of the Soviet space progam and preview the programs being planned as joint ventures between the U.S. and Russia. December 27, 6:00 PM, Einstein Planetarium.

Mount Rainier Nature & Recreation Center — "Winter Stars" Historic Bladensburg Waterfront Visitors Center, 4601 Annapolis Rd, Bladensburg, MD. Due to construction, activities at the Waterfront Center may be moved to an alternate site. Call Jean Tierney at 301/627-6074 for information. December 5, 6:30-8:00 PM.

Check your local web sites for any other events that may be happening in the area.

Cosmos Revisited December

December 2	Life as a Planetary Phenomenon By Andrew Knoll

Lectures begin at 6:00 PM at the National Air and Space Museum. For more information, call Missy Snelling at 202/357-4260.

CIW/DTM Seminars

December 3	"A Global Perspective on Galactic Evolution" By Michael Fall (STSI)
December 17	"Implications of Meteoritic Presolar Grains for Galactic Evolution" by Conel Alexander (DTM/CIW)

Seminars are held on Wednesdays at 11:00 a.m. in the Seminar Room of the Main (old) Building. Coffee and tea will be served at 10:45 a.m. Please call to confirm that there have been no cancellations. DTM is located on 32nd Street, one block south of its intersection with Military Road. Proceed south on 32nd Street, one block to Jocelyn Street, turn left on Jocelyn and right into the parking lot. CIW, 202/686-4370 (Extension 4378 or 4383)

Astronomical Events

Meteor Showers for December

Puppids-Velids	Nov 27-January (Max: Dec. 9 & Dec. 26)
Geminids	Dec 7-16 (Max: Dec 13)
Ursids	Dec 17-25 (Max: Dec 23)

Meteor web sites to explore: www.ticetboo.demon.co.uk/meteors.htm which includes a link to a site on anomalous meteor phenomena, www.maa.mhn.de/Comet/calendar.html. Also referenced is Gary W. Kronk, author of the book *Meteor Showers: A Descriptive Catalog* (1988) who is in the process of placing his book on line. He also keeps a calendar and wrote a historical piece on "Meteors and the Native Americans."

Newsletter Deadline for January *Star Dust*, December 15, 1997

Send Submissions to Alisa & Gary Joaquin, at 4910 Schuyler Dr, Annandale, VA, 22003-5144. Leave a message on voice mail 703/750-1636. Text files or graphic files in .GIF or .TIFF may be sent via E-Mail to ajglj@erols.com or fax submissions to 703/658-2233. **No submissions will be accepted after the 20th.** There will be no exceptions. We need a reasonable amount of time to design, edit, and review this newsletter. The Holidays are upon us and we would appreciate everyone's help in this matter by getting everything in on time. We will be going to Nebraska and we will need to get this mailed before December 23. Thank you.

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: 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, 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: _____
Junior members pay a reduced rate.
- [ ] *Sky & Telescope* and *Star Dust*. ($42 per year)
- [ ] Star Dust only ($15 per year)

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Street or Box Apartment City State Zip Code + 4

If family membership, list names of additional participating immediate family members in same household, with birthdates of all those under 18 years old: _____

Note: If you already subscribe to ***Sky & Telescope***, please attach a recent mailing label. You may renew this subscription through NCA for $27 when it expires.

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

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

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

_____

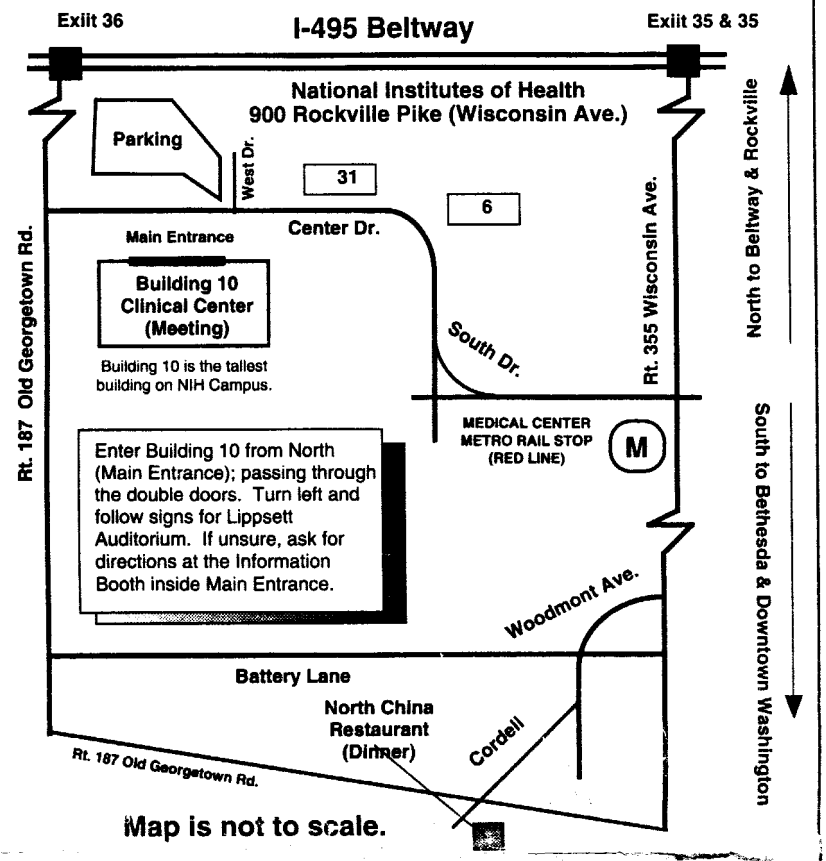
_____

Getting to the NCA Monthly Meeting

Metrorail Riders - From Medical Center Metro Station: Walk down the hill, pass the bus stops and turn right at the anchor onto Center Drive. Continue uphill to Building 10, the tallest building on campus (walking time about 10 minutes). Also, the J2 bus line connects the Bethesda (7:16 PM) and NIH (7:23 PM) Metro stops with Building 10 (7:25 PM).

To North China Resaurant- Take Wisconsin Avenue toward Bethesda and head right onto Woodmont Follow Woodmont to Old Georgetown Road and make a right. The resaurant is a few blocks on the left (7814 Old Georgetwon Road). Alternately, turn right on Cordell from Woodmont and proceed a few blocks to Old Georgetown Rd., where you will come out right near the restaurant. Park around corner.

***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. NCA's Phone Number 03/841-4765. President: Harold Williams, 301/565-3709. 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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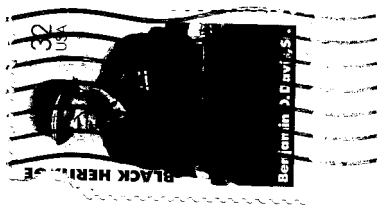

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7/98
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Rockville MD 20852-3331

December 1997