

Star Dust

Newsletter of National Capital Astronomers, Inc.

capitalastronomers.org

February 2020

Volume 78, Issue 6

**Celebrating 83 Years
of Astronomy**

Next Meeting

When: Sat. Feb. 8th, 2020
Time: 7:30 pm
Where: UMD Observatory
Speaker: Dr. Tim Livengood

Table of Contents

Preview of Feb. 2020 Talk.....	1
Recent Astronomy Highlights.....	2
Sky Watchers.....	3
TESS and Earth-Like Planets.....	3
Upcoming Wallops Launch.....	4
Occultations.....	5
Fainting of Betelgeuse Update.....	6
Calendar of Events.....	7

Directions to Dinner/Meeting

Our time and location for dinner with the speaker before this meeting is 5:30 pm at **Azteca Restaurant and Cantina** at 9505 Baltimore Avenue (Route 1), College Park, MD 20740 across from the Honda dealership.

The National Capital Astronomers meeting is held at the UMD Astronomy Observatory on Metzerott Rd about halfway between Adelphi Rd and University Blvd.

Observing after the Meeting

Following the meeting, members and guests are welcome to tour through the Observatory. Weather-permitting, several of the telescopes will also be set up for viewing.

Where Has all the Atmosphere Gone? Isotope Ratios and Atmosphere Loss from Mars

Tim Livengood

NASA's Goddard Space Flight Center and University of Maryland

Abstract: We have measured a key feature of Mars' atmosphere that supports the conclusion that Mars once had much more atmosphere than today, and which can provide constraints on how much more atmosphere it once had. What makes this measurement significant is that it comes decades after the first such measurements failed to detect the same property, and measurements since then have been inconclusive and often disagreed with each other. Atmospheric loss happens due to ultraviolet sunlight breaking up (photolyzing) molecules, releasing constituent atoms to escape to space if they have high enough thermal velocity. The lighter the atom, the more readily it escapes; the heavier the atom, the more of it is retained. As a result, in atoms of the same species, lighter isotopes tend to escape more rapidly than the heavier isotopes, resulting in an enrichment of heavy isotopes.

continued on page 2

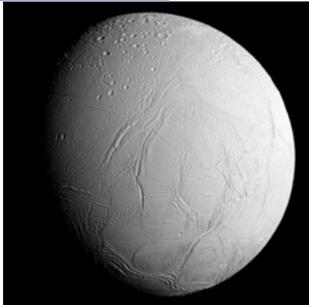


Image Credit: NASA

Recent Astronomy Highlights

Interior of Enceladus

Enceladus, an ice-covered moon of Saturn, received a number of flybys by the Cassini spacecraft during its mission. During those flybys, Cassini detected numerous plumes made up of water, hydrogen, carbon dioxide and organic materials erupting from the moon. (These jets provide the volatiles that make up Saturn's E ring.) Scientists hypothesize that the composition of the geysers indicates the interior of the moon is more complex than previously suspected. Some scientists even speculate that conditions might be conducive to the formation of life. More information can be found at www.sciencedaily.com/releases/2020/01/200122100548.htm.



Enceladus - Image Credit: NASA/JPL

7-Billion-Year-Old Star Dust

No, it's not an early issue of the NCA's newsletter. Instead, the reference in the title is to pre-solar grains (material created before the Sun formed) found in the Murchison meteorite which landed in Australia just over fifty years ago. The ages were determined by studying the amounts of transmuted elements formed within those grains by encounters with cosmic rays. The more of these elements present, the more cosmic rays encountered and therefore the older the grains are assumed to be. The grains were therefore created in at least one planetary system far older than ours. One interesting note is that while grinding up the grains for study, scientists reported a strong odor like 'rotten peanut butter'. The smell might have been caused by organic material that originally bound the grains together. More information, of an olfactory nature and otherwise, can be found at www.space.com/stardust-oldest-material-on-earth.html

continued on page 4

• [Where Has All the Atmosphere Gone? – continued from page 1](#)

• In mass spectrometer measurements on Mars as far back as Viking (1976) this pattern was observed in an enrichment of deuterium, in N-15 compared to N-14, and in Argon isotopes. In the major atmospheric constituent, carbon dioxide, the pattern broke down: the carbon and oxygen isotope ratios were essentially terrestrial. Four decades later, there have finally been two more mass spectrometers landed on Mars, as well as three published efforts to measure isotope ratios spectroscopically from Earth – including ours. Some measurements agree with terrestrial ratios, some show enrichments in one atomic species but not the other, and our measurements show isotope ratios varying with time of day. 40 years after Viking, we have a hypothetical solution to the inconsistency and unreasonable nature of many Mars isotope ratio measurements, and a guide to discerning the true isotope ratios in Mars CO₂. With improved isotope ratios, yet to be measured, we will have a way to deduce the density of Mars' primordial atmosphere and a better handle on how Earthlike an atmosphere has to be to support Earthlike features such as flowing liquid water.



• **Biography:** Dr. Tim Livengood is an Associate Research Scientist in the University of Maryland Department of Astronomy. He came to Goddard Space Flight Center in 1991 as a National Research Council postdoctoral fellow, after completing his PhD in ultraviolet spectroscopy of Jupiter's aurorae at The Johns Hopkins University. Since then, he has been affiliated with several local institutions while conducting research in planetary atmospheres at Goddard, including three stints with UMD and five years at the Challenger Center for Space Science Education. He is currently in his third and final employment run with UMD (promise!). He has worked on projects all over the Solar System with infrared, ultraviolet, and visible spectroscopy and spectrophotometry. He is a co-investigator with the Lunar Exploration Neutron Detector instrument on NASA's Lunar Reconnaissance Orbiter, to study water on the Moon. and is leading the development at Goddard Space Flight Center of the Submillimeter Solar Observation Lunar Volatiles Experiment (SSOLVE). He is a minor player in additional spaceflight instrument projects for submillimeter, ultraviolet, and neutron remote sensing methods.

Exploring the Sky



“Exploring the Sky” is an informal program that, for 70 years, has offered monthly opportunities for anyone in the Washington area to see the stars and planets through telescopes from a location within the District of Columbia. Presented by the National Park Service and National Capital Astronomers, sessions are held in Rock Creek Park once each month on a Saturday night from April through November, Beginners (including children) and experienced stargazers are all welcome—and it’s free!

Hosted by: [National Capital Astronomers, Inc](#) and [Rock Creek Park](#)

With the winter months, the Exploring the Sky program will take a hiatus until April of 2020. More information can be found at NCA’s web site, www.capitalastronomers.org or the Rock Creek Park web site, www.nps.gov/rocr/planyourvisit/expscopy.htm. You can also call the Nature Center at (202) 895-6070. For general information on local astronomical events visit www.astronomyindc.org

The article-submission deadline for February’s issue of Star Dust, is February 21st.

Clear Skies!

Sky Watchers

February/March

Mercury and Venus remain in the evening sky while Mars, Jupiter and Saturn can be seen in the pre-dawn sky.

2/9	Full Moon (and Supermoon) at 2:34 a.m. EST
2/10	Mercury at Greatest Eastern Elongation, 18.2° from the Sun and highest in western sky after sunset.
3/9	Full Moon (and Supermoon) at 10:33 a.m. EDT

TESS and Earth-like Planets in Habitable Zones

The Transiting Exoplanet Survey Satellite (TESS) is reported to have discovered its first Earth-sized planet in the habitable zone of its parent star. Designated TOI 700 d (TOI standing for Transiting Exoplanet Survey Satellite Object of Interest), the planet orbits a red dwarf 101.4 light years from the Sun. The letter ‘d’ indicates that it is the third planet in the system. (There is no planet ‘a’, and TOI 700 is actually the designation for the star itself.) Unlike the two other planets, which orbit closer to the red dwarf, TOI 700 d orbits 15 million miles from its star, in the zone where there is the possibility it could have surface water even though it may be tidally locked with that star, e.g. having the same side of the planet always facing the star. The planet is approximately 20% bigger than Earth and orbits its star every 37.4 days. A video of the discovery can be seen at www.nasa.gov/tess-transiting-exoplanet-survey-satellite.



Artist’s Impression of the Transiting Exoplanet Survey Satellite (TESS) Image Credit: NASA

continued on page 6

Upcoming Launch from Wallops Island

In the January 2020 issue of Star Dust, mention was made of NASA's Wallops Flight Facility in an article about sounding rockets. Mention was also made of the fact that the facility occasionally launches rockets carrying payloads headed for orbit. One such launch, designated NG-13 is tentatively scheduled for February 9th at 5:36 p.m. EST, one minute after sunset. At that time, if all goes as scheduled, an Antares rocket will launch a Cygnus spacecraft into orbit on a resupply mission to the International Space Station. After the Cygnus spacecraft delivers its payload and leaves the ISS, it will also be used as a platform for experiments on how fire starts and spreads through different materials and environments.

Assuming clear skies, the launch of the Antares rocket will be visible up and down the East Coast. To view the launch in the DC area, find someplace with an unobstructed view to the southeast.

As a bonus, NG-13's destination, the ISS, will have a visible pass, albeit low and to the southwest, from 6:53 p.m. to 6:57 p.m. A much more impressive and bright pass of the ISS (Magnitude -3.7) will take place the night before, February 8th, from 6:03 p.m. to 6:10 p.m. during which it will pass almost directly over the DC area. For more information on ISS passes, go to heavens-above.com/.

Because the mission is headed to the International Space Station, the launch window will be tight, so any complications – bad weather, technical difficulties or even a boat out in the restricted offshore region downrange of the launch pad – may cause the mission to be postponed. Links to information about the launch, as well as to a live feed from Wallops on the day of the launch, can be found at www.nasa.gov/centers/wallops/home.



Long exposure image of the Minotaur 1 launch from NASA's Wallops Flight Facility on November 19, 2013 taken on the upper deck of the Terrapin Trail Garage on the University of Maryland College Park campus.

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Thank you!

• [Recent Astronomy Highlights – continued from page 2](#)

• **First Vatira Asteroid Discovered**

• Vatira asteroids are defined as asteroids
 • that have an orbit contained entirely
 • within the orbit of Venus. Until now, they
 • have only been theoretical. But one has
 • finally been discovered and catalogued
 • as 2020 AV2. The asteroid was
 • discovered by the California Institute of
 • Technology's Zwicky Transient Facility
 • at the Palomar Observatory in
 • California. (By the way, asteroids with
 • orbits entirely within the orbit of Earth
 • are categorized as Atira asteroids, or
 • Apohele asteroids. Only 21 asteroids
 • having such an orbit have been
 • detected so far.) More information about
 • the discovery of 2020 AV2 is at
 • arstechnica.com/science/2020/01/astronomers-find-an-oddball-asteroid-entirely-inside-the-orbit-of-venus/

continued on page 7

Occultation Notes

- 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.
- Some stars in Flamsteed's catalog are in the wrong constellation, according to the official IAU constellation boundaries that were established well after Flamsteed's catalog was published. In these cases, Flamsteed's constellation is in parentheses and the actual constellation is given in the notes following a /.
- 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 and - 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 the main IOTA Web site.
- Sp. is the star's spectral type (color), O,B,blue; A,F,white; G,yellow; K,orange; M,N,S,C red.
- Also in the notes, information about double stars is often given. "Close double" with no other information usually means nearly equal components with a separation less than 0.2". "mg2" or "m2" means the magnitude of the secondary component, followed by its separation in arc seconds ("), and sometimes its PA from the primary. If there is a 3rd component (for a triple star), it might be indicated with "mg3" or "m3". Double is sometime abbreviated "dbl".
- Sometimes the Axis angle (AA) is given. It is the angle measured around the Moon's disk, from the Moon's axis of rotation. It can be used with a lunar map to tell where a star will reappear relative to lunar features.

Mid-Atlantic Occultations

David Dunham

Asteroidal Occultations											
2020	Day	EST/ EDT	Star	Mag.	Asteroid	dmag	dur. s	Ap. "	Location		
Feb 8	Sat	19:55	4UC493-4574	14.1	Lampetia	0.8	8 12	nVA, MD, DC, sPA, NJ			
Feb 10	Mon	4:39	nu Ser	4.3	Kolga	10.7	3 1	sTN, nGA, SC, sNC			
Feb 11	Tue	0:04	4UC60141562	12.4	Phaedra	1.2	5 8	sMD, cVA, sWV; sDE?			
Feb 11	Tue	2:23	4UC41557714	13.9	Rollandia	1.2	38 11	VA, DC, sMD; nMD?			
Feb 12	Wed	21:54	4UC48623098	13.3	Hypatia	0.5	22 10	eNC, eVA, wMD; DC?			
Feb 12	Wed	22:44	4UC53620957	13.7	Volga	1.9	45 11	DE, sMD, cVA; DC?			
Feb 17	Mon	22:59	4UC59844028	12.2	Nyanza	3.1	6 8	sNJ, sPA, OH; neMD?			
Feb 23	Sun	18:51	TYC00110327	10.7	Vera	2.5	2 5	cVA, sMD, sDE; Sn-9			
Feb 24	Mon	21:48	4UC50447105	12.4	Camilla	0.7	25 8	neNC, s&cVA, WV, OH			
Feb 24	Mon	21:49	4UC50447105	12.4	Camilla-1	0.7	1.5 8	neNC, se&cVA, cOH			
Feb 24	Mon	21:48	4UC50447105	12.4	Camilla-2	0.7	0.8 8	SC, neGA, swNC, eTN			
Mar 1	Sun	21:44	4UC43716990	13.5	Artemis	0.7	10 11	cNC, c&nVA, DC, MD			
Mar 6	Fri	3:43	TYC62320899	12.3	Hekate	1.2	4 8	sOH, cVA, sMD; DC?			

*** Dates and times above are EST, those below are EDT ***

Mar 8	Sun	20:11	4UC57820241	12.5	Brunhild	1.4	3 8	sMD, n-cenVA, cWV			
Mar 12	Thu	6:01	2UC24882807	9.9	Lova	6.1	3 4	cOH, nVA, MD, DC, DE			
Mar 12	Thu	22:33	4UC49715428	13.3	Walpurga	2.4	4 10	sOH, wMD, sePA, nNJ			
Mar 14	Sat	4:03	SAO 81278	6.5	Mombasa	8.7	5 2	s&wSC, swNC, eTN			

*This is comet 289P/BI Anpain so the prediction is very uncertain
Most event details at www.asteroidoccultation.com/

Lunar Grazing Occultations

2020	Day	EST/ EDT	Star	Mag	% alt	CA	Location, Notes	
Feb 13	Thu	5:44	SAO 139321	9.0	77-	40 13S	nPotomac, NI H, neDC, Marl ton, MD	
Mar 12	Thu	5:26	ZC 1994*	6.6	90-	38 15S	Bul lRun, Dal eCi ty, VA; Ri son, MD	

Links for interactive maps are at iota.jhuapl.edu/exped.htm XX

Lunar Total Occultations

2020	Day	EST/ EDT	Ph Star	Mag	% alt	CA	Sp.	Notes	
Feb 11	Tue	23:19	R 16 Vir	5.0	88-	28	24N K1	The star is ZC 1773	
Feb 12	Wed	3:32	R ZC 1783	7.3	87-	53	77S A0		
Feb 12	Wed	23:26	R SW Vir	7.1	79-	16	79S M7	SAO 139236, phase 46%	
Feb 13	Thu	5:59	R ZC 1923	7.0	77-	39	80N K0	mg2 11, sep .4", PA 239dg	
Feb 15	Sat	2:56	R HI Li brae	7.5	56-	25	30N AP	SAO 159050	
Feb 16	Sun	4:06	R ZC 2301	6.7	45-	23	88S F5	mg2 11, sep 75", PA 236dg	
Feb 16	Sun	6:43	R SA0159731*	7.8	44-	32	83S A0	Sun -4, mg2 10 sep 1.0"	
Feb 17	Mon	3:53	R ZC 2445	7.4	34-	12	76N K0	Azimuth 131 degrees	
Feb 17	Mon	6:56	R SA0185012*	7.1	33-	29	59S B5	Sun altitude -1 deg.	
Feb 18	Tue	7:26	D Mars	1.2	24-	26	-83N	Sun +5, AxisAngle 84deg	
Feb 18	Tue	8:58	R Mars	1.2	23-	27	65N	Sun altitude +21 deg.	
Feb 26	Wed	19:53	D SAO 109577	7.7	10+	10	54N K5	Az 263, mag2 9 sep. 30"	
Feb 29	Sat	20:54	D SAO 93362	8.0	33+	31	27N F8		
Mar 1	Sun	20:46	D ZC 600	6.6	42+	43	42S K2	mag2 9.6 sep .5" PA 109	
Mar 3	Tue	22:15	D SAO 77710	7.2	63+	48	90N G7		
Mar 4	Wed	1:32	D ZC 911	6.4	64+	12	77S B8	Az 289, close double??	
Mar 4	Wed	18:10	D ZC 1036	6.5	72+	62	35N G8	Sun altitude -2 degrees	
Mar 4	Wed	19:11	D SAO 78758	7.5	72+	71	79N G5		
Mar 4	Wed	19:42	D SAO 78771	6.8	72+	74	86N A0		
Mar 5	Thu	21:44	D 84 Gem	7.1	82+	71	82S K0	ZC 1187	
Mar 6	Fri	21:39	D ZC 1329*	6.8	90+	70	57S F8	mag2 7.9" sep .2" PA 66	
Mar 9	Mon	19:14	R nu Vir	4.0	100-	10	61N M0	Az90, AA254, ZC1702, TmD4"	
Mar 11	Wed	23:09	R SAO 139528	7.2	91-	15	35N K0	Azimuth 110 degrees	
Mar 12	Thu	0:54	R ZC 1976	7.0	90-	31	78S A3		
Mar 12	Thu	1:26	R 88 Vir	6.6	90-	35	79S K0	ZC 1978; close double??	
Mar 12	Thu	5:32	R ZC 1994*	6.6	89-	36	26S F8	double, see nVA graze	
Mar 13	Fri	3:36	R ZC 2110	6.3	82-	37	82S K0		
Mar 13	Fri	4:06	R SAO 158815	7.7	81-	38	46S K0		
Mar 14	Sat	6:51	R ZC 2259*	6.8	71-	30	70N F3	Sun altitude -6 degrees	
Mar 14	Sat	7:02	R SA0159520*	7.6	71-	29	63S F2	Sun -4, close double??	

*in Kepler2 program so occultation light curves are sought.

More, esp. total lunar occultations, at iota.jhuapl.edu/exped.htm
David Dunham, dunham@starpower.net

continued on page 6

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Occultations – continued from page 5

Feb. 24: (107) Camilla has two satellites, whose paths are also predicted to cross the Mid-Atlantic, so separate predictions are given for them, following the prediction for the main asteroid occultation. I call the first satellite Camilla-1 but its official designation is S/2001 (107) 1; it is thought to be 15 km in diameter. Camilla-2 is officially known as S/2016 (107) 1 and is about 8 km in size. Details for each event are at www.asteroidoccultation.com/2020_02/0225_107_64272.htm.

TESS and Earth-like Planets in Habitable Zones – continued from page 3

More information about the discovery of TOI 700 d can be found at astronomynow.com/2020/01/07/tess-finds-its-first-earth-size-planet-in-host-suns-habitable-zone/ and the paper announcing the discovery is available at arxiv.org/pdf/2001.00954.pdf.

It should be noted that TOI 700 d is not the first such Earth-like planet in a star's habitable zone that has been discovered. Other such planets were discovered by the Kepler Space Telescope and the Transiting Planets and Planetesimals Small Telescope (TRAPPIST). Indeed TRAPPIST-1, a red dwarf star just under forty light years away, has three planets that appear to be in its habitable zone.

The closest potentially habitable planet is Proxima Centauri b, which is only 4.2 light years away, orbiting the red dwarf, Proxima Centauri, the closest star to the Sun and one member of a trinary star system. The planet is approximately 1.27 times the mass of the Earth.

At the other of the distance spectrum are several such potentially habitable planets discovered by the Kepler Space Telescope during its mission (2009 – 2018). These candidates are up to 1200 light years away from the Sun.

A catalog of potentially habitable planets is maintained by the Planetary Habitability Laboratory (PHL) at the University of Puerto Rico at Arecibo, and can be found at phl.upr.edu/projects/habitable-exoplanets-catalog. So far there are one Mars-sized candidate, 20 Earth-sized candidates and 34 Super-Earth/Mini-Neptune candidates. This number will no doubt increase in coming years.

Fainting of Betelgeuse Update

Betelgeuse, the variable red giant star, continues to fade, or 'faint' as astronomers say, recently down to a magnitude of 1.506. But as of the time of writing this article (1/24/20), the fading appears to have slowed down. As mentioned in the January 2020 issue of Star Dust, the fading may have been caused by obscuring from gas and dust expelled by Betelgeuse. However, if such obscuring is not the cause, then the fading seems to imply that the star has cooled by approximately 100 kelvins (K) and has increased in radius by around 9% since September 2019. More information on the fading can be found in a report filed at www.astronomerstelegram.org/?read=13410 and in an article at spaceweatherarchive.com/2020/01/10/the-fainting-of-betelgeuse-update/. Also a graph of the star's magnitude in recent months is at www.aavso.org/sites/default/files/Screen%20Shot%202020-01-13%20at%209.41.41%20AM.png. Meanwhile astronomers continue to monitor the situation and speculate about the cause.

Recent Astronomy Highlights – continued from page 4

Strange Neighbors of Sagittarius A*

Objects that “look like gas and behave like stars”, according to Andrea Ghez of UCLA, appear to be members of a new class of astronomical objects. These objects, which orbit Sagittarius A*, the supermassive black hole at the center of the Milky Way galaxy, are compact when they are far out in their orbits, but stretch out when they orbit closer to the supermassive black hole. Six such objects, labeled G1 – G6, have been identified so far. Speculation is that these objects are each the result of mergers of a pair of stars, with the gas and dust surrounding them still settling down on the larger star that was created. Such mergers may be common in the extremely star dense galactic center. Gas stripped from these objects during their closest approaches may cause brightening around Sag A* as it feeds into the supermassive black hole. More information can be found at newsroom.ucla.edu/releases/astronomy-strange-objects-galaxy-black-hole

Calendar of Events

- **NCA Mirror- or Telescope-making Classes:** Tuesdays AND Fridays, from 6:30 to 9:30 pm at the Chevy Chase Community Center (intersection of McKinley Street and Connecticut Avenue, N.W.) Contact instructor Guy Brandenburg at [202-635-1860](tel:202-635-1860) or at gbrandenburg@yahoo.com.
- Additional information is at guysmathastro.wordpress.com/ and home.earthlink.net/~gbranden/GFB_Home_Page.html
- **Open house talks and observing at the University of Maryland Observatory** in College Park on the 5th and 20th of every month at 8:00 pm (Nov.-Apr.) or 9:00 pm (May-Oct.). Details: www.astro.umd.edu/openhouse
- **Next NCA Meeting** at the University of Maryland Observatory: **14 March** 7:30 p.m., Tony Farnham, (UMD), *A Cometary Outburst, Watched As It Develops*
- **The APS Mid-Atlantic Senior Physicists Group:** “LIGO-Virgo Gravitational-Wave Findings So Far, and Current Events” by Peter Shawhan, University of Maryland, Feb. 19th at 1:00 pm at the American Center for Physics (1st floor conference room). 1 Physics Ellipse, College Park MD -- off River Rd. between Kenilworth Ave. and Paint Branch Parkway. For more information on the talk, go to www.aps.org/units/maspg/meetings/meeting.cfm?name=SENIOR0220. More information about the APS Mid-Atlantic Senior Physicists Group can be found at www.aps.org/units/maspg/index.cfm.

National Capital Astronomers Membership Form

Name: _____ **Date:** ___/___/___

Address: _____ **ZIP Code:** _____

Home Phone: ___-___-___ **E-mail:** _____ **Print / E-mail Star Dust (circle one)**

Membership (circle one): Student..... \$ 5; Individual / Family.....\$10; Optional Contribution.....\$__

Please indicate which activities interest you:

- Attending monthly scientific lectures on some aspect of astronomy _____
- Making scientific astronomical observations _____
- Observing astronomical objects for personal pleasure at relatively dark sites _____
- Attending large regional star parties _____
- Doing outreach events to educate the public, such as Exploring the Sky _____
- Building or modifying telescopes _____
- Participating in travel/expeditions to view eclipses or occultations _____
- Combating light pollution _____

Do you have any special skills, such as videography, graphic arts, science education, electronics, machining, etc.?

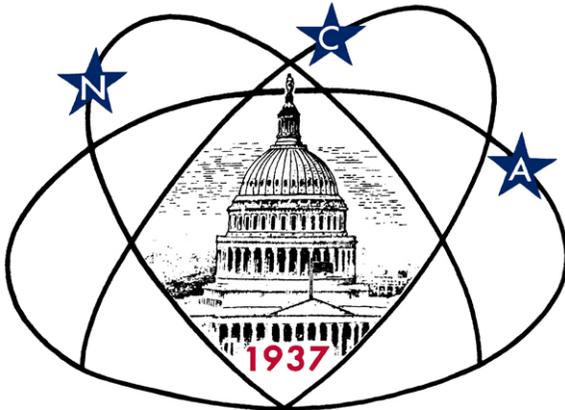
Are you interested in volunteering for: Telescope making, Exploring the Sky, Star Dust, NCA Officer, etc.?

Please mail this form with check payable to **National Capital Astronomers** to:
Henry Bofinger, NCA Treasurer; 727 Massachusetts Ave. NE, Washington, DC 20002-6007

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Dated Material



Celebrating 83 Years of Astronomy

Next NCA Meeting:

2020 February 8th

7:30 pm

@ UMD Observatory

Dr. Tim Livengood

Inside This Issue

Preview of Feb. 2020 Talk.....	1
Recent Astronomy Highlights.....	2
Sky Watchers.....	3
TESS and Earth-Like Planets.....	3
Upcoming Wallops Launch.....	4
Occultations.....	5
Fainting of Betelgeuse Update.....	6
Calendar of Events.....	7