Star Dust

National Capital Astronomers, Inc.

January 2010

Volume 68, Issue 5

http://capitalastronomers.org

Next Meeting

When: Sat. Jan. 9, 2010

Time: 7:30 pm

Where: UM Observatory

Speaker: Peter Teuben, University of Maryland

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Directions to Dinner/Meeting

Members and guests are invited to join us for dinner at the Garden Restaurant located in the UMUC Inn & Conference Center, 3501 University Blvd E. The meeting is held at the UM Astronomy Observatory on Metzerott Rd about halfway between Adelphi Rd and University Blvd.

Need a Ride?

Please contact Jay Miller, 240-401-8693, if you need a ride from the metro to dinner or to the meeting at the observatory. Please try to let him know in advance by e-mail at rigel1@starpower.net.

January 2010: Dr. Peter Teuben
University of Maryland
The Dynamics of Barred Galaxies

Abstract: Galaxies come in two kinds: Disk and Elliptical, depending on where, when and how they were formed. Disk galaxies usually have a well defined two-armed spiral, and about half of them have a strong large dominant linear bar through the center. Astronomers discovered fairly early on that this bar was not just a spinning object: like the spiral arms of galaxies, the bars have something to do with what we call density waves. This talk will also discuss how we have found that bars play an important role in the evolution of galaxies in the very early universe, and what puzzles still remain.

Biography: Peter Teuben got his PhD at the University of Groningen in 1986, and after postdocs in Princeton (NJ) and Urbana-Champaign (IL), since 1989 he has been working with the mm radio interferometer group at the University of Maryland at College Park. Initially there were twelve 6m dishes, called the Berkeley-Illinois-Maryland array (BIMA). But then nine of these dishes were merged with the Owens-Valley mm array (OVRO, 6 10m dishes), and eight more 3.5m dishes were added from the Chicago-based SZA group. This expanded array is now called CARMA (Combined Array for Research in Millimeter Astronomy). His role in this group is writing the software that runs the telescopes, and the software that turns the complex data that an interferometer produces into pretty pictures. In addition Dr. Teuben also works on theoretical software that simulates galaxies and star clusters. Dr. Teuben also plays a mean game of badminton, a popular sport in his native Holland.

Astronomical Distances

Presented by Dr. Robert Olling

Reviewed by Wayne H. Warren Jr.

Dr. Rob Olling of the University of Maryland astronomy department was the featured speaker at the October 10 monthly meeting of the National Capital Astronomers, which was held at the University of Maryland observatory.

The original title of Dr. Olling's talk, as advertised in the October *Star Dust*, was "Proper Motions within Andromeda". This was generalized to the more appropriate title given above, since the talk was more about astronomical distances in general and what we can expect from future space missions such as the European Gaia astrometric mission and the U.S. SIM (Space Interferometry Mission).

Dr. Olling began his talk by noting that the future of highly accurate positional

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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.

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Thank you!

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astronomy (known as astrometry) lies in space, where one doesn't have to contend with the Earth's atmosphere and where very stable platforms are now routinely produced. The wonderfully successful HIPPARCOS (High Precision PARallax COllecting Satellite) measured positions and proper motions for about 118,000 stars on its main program. For the brighter stars on the program, which was complete down to magnitude 7.3, the accuracy at epoch (1991.25) was about a millisecond of arc. A less accurate instrument named Tycho measured positions, proper motions, brightnesses, and colors using data from the satellite star mappers. Data were initially reduced for about a million stars, 97% complete down to magnitude 10. The Tycho 2 catalog was later constructed by reanalyzing the Tycho data and combining them with previous astrometric catalogs. This work produced a catalog of about 2.5 million stars that is 99.9% complete to approximately magnitude 11.0. By using much older positional catalogs, such as the series of astrographic catalogs that are up to a century old, a significant improvement in the proper motions was achieved. The Hipparcos and Tycho 2 catalogs have been eminently successful in producing significant advances in astronomy and astrophysics because they have produced accurate stellar distances out to about 100 parsecs (300 light years). Thus, the astrophysical properties of most stellar types in the Hertzsprung-Russell diagram are now known quite well.

The next in the series of European astrometric missions is the Gaia astrometry satellite (http://www.esa.int/esaSC/120377_index_0_m.html). Its goal is to conduct a census of about a billion stars in the Milky Way Galaxy, measuring positions, proper motions, parallaxes, radial velocities, and multicolor brightnesses for every star down to roughly magnitude 20. The astrometric accuracy for the brighter stars is expected to be 8 microseconds of arc, about a hundred times better than Hipparcos. Note that the number of stars with good accuracy increases roughly as the volume, so Gaia will produce about $100^3 = 10^6$ more stars with good accuracy as Hipparcos did. Gaia is also expected to detect and characterize tens of thousands of extrasolar planetary systems, discover tens of thousands of new asteroids in the Solar System as well as distant quasars, and will have the capability to provide stringent new tests of the General Theory of Relativity. This work will be achieved by measuring positional accuracies of about 24 microseconds of arc (0.000024″) at magnitude 15 (comparable to measuring the diameter of a human hair at a distance of a thousand kilometers). The scientific knowledge gained from the analyses of these data in many areas of astronomy and astrophysics is almost inconceivable.

The comparable US space astrometry mission is called SIM (Space Interferometry Mission), now better known as the SIM Lite Astrometric Observatory (http://planetquest.jpl.nasa.gov/SIM/index.cfm). This mission will use optical interferometry to achieve very high resolution to measure stellar distances throughout the Galaxy and to study planetary systems of other stars and quasars out to the edge of the Universe. While Gaia is essentially a survey mission, SIM Lite is a targeted mission that will observe with increased accuracy stars and other interesting objects detected by Gaia.

Dr. Olling then briefly discussed the history of positional measurements in astronomy, showing how Aristarchus of Samos attempted to use Full Moon geometry in about 250 BC to measure the distance to the Sun. Hipparchus estimated the distance to the Moon (ca. 150 BC) from daily lunar parallax and by observing a solar eclipse from two locations (Alexandria and Nicaea

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[in what is now Turkey]). While early astronomical distance measurements used only geometry, Newton was able to quantify the process by introducing his universal law of gravitation.

Although Aristarchus suggested the heliocentric model, the fact that no shifts in the positions of stars could be seen as the Earth moved did not support the heliocentric hypothesis. Of course, we now know that the stars are so far away that the parallactic angle shifts are very small. It was not until 1838 that Bessel announced that he had measured a parallax of 0.314 seconds of arc for the nearby star 61 Cygni, which gave a distance of about 3 parsecs. In contrast, the European Space Agency's HIPPARCOS astrometric mission was able to accurately measure parallaxes to 1 mas, about a thousand times better than the angular displacement of the closest star system (α Centauri) to the Solar System. Dr. Olling noted that the parallax method is the only fundamental distance determination method; all others, such as spectral types, pulsations of RR Lyrae and δ Cephei variables, etc., being dependent on the intrinsic properties of the objects. He compared the astrometric distance scale in terms of parallaxes and proper motions for α Cen (742,000 µas; 1,000,000 µas yr^{-1}), the galactic center (125 µas; 5,275 µas yr^{-1}), the Large Magellanic Cloud (LMC) (20 µas; 211 µas yr^{-1} for 50 km s^{-1}), and M 31 (1.5 µas; 60 µas yr^{-1} for 200 km s^{-1}). This can be compared to the width of the USA as seen from 10 pc (2.6 µas) and the motion of the Sun as a result of tugging by the Earth of 1 µas yr^{-1}). Another neat analogy is that 1 µas is equivalent to measuring from the Earth the width of a nickel held by an astronaut standing on the surface of the Moon.

Dr. Olling stressed that, while past accuracy in astronomy meant within a factor of two, we are now in the 1% century, meaning that not only should repeated measurements agree to within a percent, but the error bars should overlap if the data are to be believed. He used examples of the age of the Universe now being known to about 0.8% and the Hubble constant to about 1.8%. The accuracy requirement implies that future missions (Gaia, SIM) must measure the ages of stars and clusters to better than 1% (distances to 0.5% or better) and the distance scale to 1% or better. Of course, the goal of making these astronomical measurements is to understand the physics behind what we observe. When we measure stellar distances, we not only gain understanding of the structure and motions of stars in the Galaxy, but we gain insight into stellar temperatures, sizes, luminosities, etc., and that leads to increased understanding of stellar energy generation and lifetimes. More important than increased precision (internal agreement of observations) is increased accuracy (agreement of measurements with the "real" values), which is what is really needed to effect understanding of the physical world.

Dr. Olling next discussed the extragalactic distance scale. All geometric methods of measuring this scale are still problematical. Examples are the Baade-Wesselink method for cepheids (measuring the expansion of the atmosphere and brightness changes), observing H_2O masers in extragalactic star-forming regions, eclipsing binaries, etc. The rotational parallax method to be discussed later, does not seem to have these problems and promises to provide highly accurate results for galaxies of the Local Group.

Dr. Olling then turned to cosmology and discussed the important information needed to understand the evolution and future of the Universe. The critical density, $\rho_{crit} = 3H^2 / 8\pi G$, is a fundamental quantity on which everything depends.

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Since this depends on the Hubble constant, H, any uncertainty in H translates directly to ρ_{crit}. The total matter density of the Universe is the sum of the densities of baryons and dark matter particles (whatever they are), and its ratio to the critical density ($\Omega_m = ((\rho_b + \rho_{DM}) / \rho_{crit}) = \omega_m / h^2$, where ω_m is the ratio of the physical matter density to the critical density for H = 100 and h is H/100. Thus, the important cosmological parameters all depend on H, meaning that it is very important to determine the Hubble constant to the best accuracy that we can.

Improvement of the value of H can be made by refining the methods mentioned above, but there is a direct way to measure H in the local Universe, which is what Dr. Olling turned to next. The rotational parallax method was actually developed by Deane M. Peterson (SUNY Stony Brook) and Michael Shao (JPL) while they were working on SIM in its early days. The principle is quite simple and involves the measurement of proper motions and their relation to distance and angular velocity. The method is capable of yielding accuracies of several percent out to a megaparsec, but requires large-scale ordered motions (i.e., galaxy rotation), ground-based radial velocities, and space-based proper motions at the 10 µas per year level. Using the Andromeda Galaxy (M 31) as an example, Dr. Olling showed the radial and transverse motions required to determine the space motions of the component stars. The proper motions occur in two directions for the two transverse directions at the front and rear of the galaxy, while the radial velocity depends on the circular velocity and the angle of inclination; viz.:

$$\mu_x = V_c / \kappa D,$$
$$\mu_{y'} = V_c \cos(i) / \kappa D,$$
$$V_R = V_c \sin(i),$$

where κ is a constant that depends on the choice of units (it is 4.74 if D is in Mpc and the proper motions are expressed in µas/year). Thus, we have three unknowns (V_c, i, and D) and three equations. Dr. Olling showed that the equations can be solved for the general case (any position in the galaxy), the case of a flat rotation curve and circular orbits with an inclination known from measuring neutral hydrogen (H I), and the latter with unknown inclination. He also described how various other scenarios (space motion of the galaxy, warping of the spiral shape, non circular motions, and rotation of the astrometric grid) can be handled. The rotational parallax method is shown to be very robust if the motions can be measured well enough. He discussed the method of rotational parallaxes in general and the situations in which solutions are and are not obtainable.
(See the reference http://arxiv.org/PS_cache/astro-ph/pdf/0005/0005484v1.pdf for further details.)

The rotational parallax method does require that bright stars be available, that there be enough of them to give reliable statistics, and that the least disturbed galaxies be used. The Local Group (LG) galaxies M 31 in Andromeda and M 33 in Triangulum are the best candidates for the SIM mission. He then compared SIM to Gaia in terms of performance. He concluded his talk with the following points:

- We will be able to measure galaxy distances in the LG to within 1% with Gaia and SIM data; SIM will be able to do M 31 and M33 in a reasonable amount of time, while Gaia should be able to do the LMC and possibly the SMC and M 31.
- The accurate distances to LG galaxies will allow us to calibrate the other methods mentioned earlier (cepheids, RR Lyrae stars, eclipsing binaries, etc.). This, in effect, transfers the solar neighborhood calibration for stars to LG galaxies.
- Other methods will become available for cross checks.
- The bottom line is that the Hubble Constant is such an important cosmological parameter that a major effort to pin its value down is warranted. SIM and Gaia should be able to provide the data to realize this goal.

The NCA is indebted to Dr. Olling for this engaging and fascinating talk on distance determinations in astronomy. It is now very well understood that accurate distances can be determined out to at least several Mpc from the Milky Way and that accurate distances are needed to provide astronomical as well as astrophysical information on objects in the Universe. This reviewer thanks Dr. Olling for providing his PowerPoint presentation as well as reading over this review and suggesting changes prior to publication.

A Winter Blast of Fun! January, 2010

By Tom Koonce
Antelope Valley Astronomy Club, Inc.
Lancaster, California

The weather is often keeping us inside at this time of year. The only stars we get to see are those as we are dashing from the car to the house in the evenings. For a few seconds we may glance up at Orion's Belt or perhaps a bright planet through bitterly cold, but alluringly steady, clear skies. You might briefly think about going inside and grabbing your telescope and coming back out for a few minutes of observing, but then the choice between the bitter cold and the Siren's song of the warmth of the house becomes clear as you retreat inside. It's frustrating, surely, but while amateur astronomy is a hobby that teaches patience and perseverance we don't want to sit idly by all winter.

Perhaps we should treat the winter months as an "opportunity". We could use these few months to explore our creativity, get our equipment finely tuned and ready, or even expand our horizons online by conducting real science for professional astronomers. With that in mind, here are a few ideas for the winter months. Maybe you'll like to try a few. These could count as New Year's Resolutions. All count as fun!

- Clean all of your eyepieces (http://www.televue.com/engine/page.asp?ID=143)

- Clean your telescope (http://www.ehow.com/how_10336_care-telescope.html)

http://sctscopes.net/SCT_Tips/Maintenance/Cleaning_Your_Optics/cleaning_your_optics.html)

- Change the batteries in your Telrad, red light flashlights and other powered accessories.

- Inventory all of your astronomy gear. Take pictures of all of it for insurance purposes.

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Mid-Atlantic Occultations and Expeditions

Dr. David Dunham

Asteroidal Occultations

Date	Day	EDT	Star	Mag.	Asteroid	dmag	dur. s	Ap. "	Location
Jan 9	Sat	23:42	2UC33888820	11.5	Barbara	1.5	3	7	neNC,scVA,sWV,KY
Jan 11	Mon	1:12	TYC12951316	11.1	Ophelia	1.9	13	7	s&wMD,DC,nVA,nWV
Jan 14	Thu	22:01	TYC24850738	10.3	1999 LS26	5.1	1	5	sNJ,sPA,nMD?,OH
Jan 16	Sat	21:24	2UC36227390	12.8	Minerva	1.0	8	10	WV,nVA,MD,DE
Jan 22	Fri	5:06	2UC40347689	11.0	Hanskya	3.3	5	7	e&nVA,nWV,OH;DC?
Jan 27	Wed	19:24	2UC42382386	11.9	Ljuba	2.6	9	7	seNY,ePA,wMD,wVA
Jan 28	Thu	3:34	TYC19810358	10.9	Takuboku	5.1	3	6	sNJ,ePA;DE,eMD?
Jan 28	Thu	21:37	TYC12200449	11.8	Emma	2.4	8	7	OH,sPA,MD,DE
Jan 29	Fri	23:39	TYC49010831	12.2	Kleopatra	0.5	11	8	sNew England, NY
Feb 2	Tue	19:48	14 Tauri	6.3	Jugurtha	8.3	4	2	nMO,nIL,lowerMI

Lunar Grazing Occultations (*, Dunham plans no expedition)

Date	Day	EDT	Star	Mag.	%	alt	CA	Location
Jan 11	Mon	6:06	ZC 2360	8.3	13-	11	11S	New Freedom, PA; Bel Air, MD
Jan 11	Mon	7:40	Antares	1.1	13-	19	7S	Boston&CapeCod,MA(day);neOnt.
Jan 28	Thu	3:08	SAO 78707	7.2	94+	29	13N	*Plymouth, PA
Feb 1	Mon	3:31	ZC 1566	6.3	93-	49	6S	Marston,Columbia,Odenton, MD
Feb 3	Wed	2:21	SAO 138822	7.8	77-	38	9S	neOH;Chantilly&Woodbridge,VA
Feb 5	Fri	2:39	ZC 2046	7.0	56-	16	8S	*Garisn&Holtsv,NY;Stamford,CT

Total Lunar Occultations

DATE	Day	EDT	Ph	Star	Mag.	%	alt	CA	Sp.	Notes
Jan 8	Fri	2:36	R	ZC 1960	6.7	40-	11	90N	K3	Az 122, close double
Jan 10	Sun	5:01	R	SAO 183520	8.2	21-	12	83N	A5	Az 135
Jan 10	Sun	7:04	R	SAO 183565	7.1	20-	24	62S	A3	Sun-5,comp.ZC2220,dbl.
Jan 10	Sun	7:05	R	ZC 2220	7.0	20-	24	62S	A3	CloseDbl;SAO183565R+20s
Jan 12	Tue	6:16	R	SAO 185305	7.5	7-	6	84S	A2	Az 131
Jan 18	Mon	18:40	D	SAO 146144	8.3	11+	21	61N	K2	
Jan 18	Mon	19:46	D	SAO 146159	7.9	11+	9	38N	K0	Az 256
Jan 23	Sat	19:28	D	SAO 92940	7.9	55+	66	65N	K0	
Jan 23	Sat	22:28	D	26 Arietis	6.1	56+	35	79N	A9	ZC 370, close double?
Jan 24	Sun	0:18	D	SAO 93005	7.9	57+	14	88N	K0	Az 284
Jan 24	Sun	23:43	D	66 Arietis	6.2	67+	32	7S	K0	ZC 501, close double
Jan 26	Tue	1:11	D	ZC 683	7.4	78+	28	46N	A2	
Jan 28	Thu	0:29	D	ZC 1024	7.4	94+	58	54S	F5	
Jan 28	Thu	3:01	D	SAO 78707	7.2	94+	30	36N	K2	
Jan 28	Thu	3:10	D	ZC 1036	6.5	94+	28	88S	G8	
Jan 28	Thu	4:20	D	SAO 78771	6.8	94+	15	82N	A0	Az 288
Jan 28	Thu	18:06	D	ZC 1143	6.8	98+	24	88N	G5	Sun -8, close dbl?
Jan 29	Fri	0:49	D	79 Gem	6.5	98+	63	46S	A1	ZC 1171, Term.Dist. 17"
Jan 30	Sat	21:23	R	ZC 1423	6.7	99-	33	73S	A3	WA 268
Jan 31	Sun	0:34	R	SAO 98747	6.9	98-	60	23N	K5	WA 352,TmD 4
Feb 1	Mon	1:23	R	34 Sex	6.7	94-	53	34N	F5	WA 336, ZC 1564, double
Feb 7	Sun	6:00	R	SAO 184209	7.7	35-	23	41S	K0	mag2 8.0 sep 4", PA 279
Feb 8	Mon	5:33	R	BF Oph	7.5	26-	16	66S	G0	SAO 185020, spec. bin.
Feb 8	Mon	6:06	R	2458	6.3	26-	19	89S	B8	

Explanations & more information are at http://iota.jhuapl.edu/exped.htm.
David Dunham, dunham@starpower.net, phone 301-526-5590

Timing equipment and even telescopes can be loaned for most expeditions that we actually undertake; we are always shortest of observers who can fit these events into their schedules, so we hope that you might be able to.

Information on timing occultations is at: http://iota.jhuapl.edu/timng920.htm.

Good luck with your observations.

An Appeal to Help the Owens Science Center

By Craig Levin

The Owens Science Center (http://www1.pgcps.org/howardbowens/) is a special institution within Prince George's County. Unlike students in other school systems in our area, the students in Prince George's County's schools have an opportunity to experience nature in a hands-on fashion through the Owens' labs, terraria, nature trail, & planetarium.

The Owens also hosts occasional "Family Science Nights", in which the staff presents demonstrations of scientific laws to all comers for free. On the second Friday of every month, the planetarium hosts sky shows that are open to the public for a small fee ($4 for an adult, $2 for students, senior citizens, & teachers, free for children 3 & under), which can be reduced even further by presenting your membership card for the Planetary Society. The fees for the sky show go to supplies for the planetarium. Recently, the Owens acquired an auxiliary console for the planetarium, that will allow a speaker to run some of the basic elements of a sky show without having to run to the back or ask someone to operate the planetarium's projectors while the presentation is going on.

Unfortunately, because the Owens is a resource for the entire county, it's more vulnerable to budget & staffing cuts than neighborhood schools, which have parents & local leaders to speak for them. Right now, the school system in Prince George's County is under a lot of financial pressure, due to the hardship that has generally gripped our country. The Owens is in a vulnerable position, as a school-funded institution without a body of parents directly linked to it.

The Owens needs our support. The high-stakes testing for students across the county will include science testing next year, so the need for a dedicated science center like the Owens will be great. The school board needs to know that the Owens is a vital link in the chain for their students' success. The board has a general address linked through their webpage (http://www1.pgcps.org/board/). The Owens also can use volunteers. If you are interested in volunteering, you can always email the Owens through the link on its webpage.

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- Organize your eyepiece case and / or make a new eyepiece case (http://www.cloudynights.com/item.php?item_id=1090)

- Image process all of those great shots that you've been meaning to get to (http://www.spacetelescope.org/projects/fits_liberator/improc.html)

- Accomplish real science on your home computer – help scientists classify galaxy types: (http://www.galaxyzoo.org/)

- Build a model of the Cassini Spacecraft (or many others!) (http://www.jpl.nasa.gov/scalemodels/)

- Establish an "astronomy fun fund" for yourself and put $5/week into it

- Write a few letters to your town in favor of lighting control (http://www.darksky.org/)

- Review the Astronomical League list of observing clubs. There are a few new ones you might like try. (http://www.astroleague.org/observing.html)

- Repaint your old telescope with a cool pattern (http://www.cloudynights.com/ubbthreads/showflat.php/Cat/0/Board/classics/Number/2294472/page/0/view/collapsed/sb/5/o/o/fpart/all)

- Update your GoTo software on-line to the latest version

- Build your own Dobsonian telescope (http://www.backyardvoyager.com/dobplans.html)

- Create a list of community outreach activities that you think your club might be able to do this year.

- Sketch out what your backyard observatory will look like one day (http://obs.nineplanets.org/obs/obslist.html)

- Survey your club members about what was their best astronomy-related experience this past year. Try to have more of those this next year.

- Make a glare shield for your telescope from black foam craft sheet (http://www.atoztelescopes.com/products/dew_shield.asp)

- Listen to an astronomy related podcast on your computer (http://www.astronomycast.com/)

- Write a letter to your state congressmen and senators in favor of the space program

- Explore Google Moon and Google Mars

- Make a cover for your telescope when not in use

I hope that you find this short list inspirational on the cold, dark, days of winter and that it prepares you for the upcoming warmer weather and "Messier Marathon" in March.

Science News

Thank you Nancy Grace Roman for finding this article.

Tiny Galaxies

from Carnegie Science
Fall 2009

The Milky Way is surrounded by incredibly small, round and dim galaxies. Some contain only a few hundred stars and glow with the light of only 1000 suns. Because the galaxies are 100 to 1000 more massive than predicted from their brightness, 99% of their mass must be in the form of dark matter. Their stars are among the most metal poor and thus the oldest known. Cosmological models predict that there should be hundreds of satellite galaxies surrounding the Milky Way. Only a couple of dozen are known but as only 1/5 of the sky has been surveyed for them to date, there may easily be nearly 100 in the Milky Way family.

Calendar of Events

NCA Mirror- and Telescope-making Classes: Fridays, Jan. 8, 15, 22, and 29, 6:30 to 9:30 pm at the Chevy Chase Community Center, at the northeast corner of the intersection of McKinley Street and Connecticut Avenue, N.W. Contact instructor Guy Brandenburg at 202-635-1860 or email him at gfbrandenburg@yahoo.com. In case there is snow, call 202-282-2204 to see if the CCCC is open.

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). There is telescope viewing afterward if the sky is clear.

Dinner: Saturday, Jan. 9 at 5:30 pm, preceding the meeting, at the *Garden Restaurant* in the University of Maryland University College Inn and Conference Center.

Upcoming NCA Meetings at the University of Maryland Observatory

Jan. 9, 2010
Peter Teuben (U. MD)
The Dynamics of Barred Galaxies

Feb 13, 2010
Scott Sheppard (DTM)
Satellites of the Giant Planets

Yes, I'd like to join NATIONAL CAPITAL ASTRONOMERS!

Name: .... Date: _____/_____/______

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Would you prefer to get Star Dust by e-mail? __________

MEMBERSHIP CATEGORIES AND ANNUAL DUES RATES

All members receive Star Dust, the monthly newsletter announcing NCA activities. The basic dues cover an electronic copy of Star Dust; paper copies are $10 extra. You may also choose to get Sky & Telescope magazine at the discounted rate of $33.

Student Membership .... $ 5
Paper copy of Star Dust $10
Sky & Telescope $33
Total .... ______

Individual/Family Membership $10
Paper copy of Star Dust $10
Sky & Telescope $33
Total .... ______

Please mail this form with your check payable to National Capital Astronomers to:
Mr. Michael L. Brabanski, NCA Treasurer; 10610 Bucknell Drive, Silver Spring, MD 20902-4254

National Capital Astronomers, Inc.

If undeliverable, return to
NCA c/o Michael L. Brabanski
10610 Bucknell Dr.
Silver Spring, MD 20902-4254

First Class
Dated Material

Next NCA Mtg:

Jan. 9

7:30 pm

@ UM Obs

Dr. Peter Teuben

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