ATM of BOSTON Established 1934

STAR FIELDS

Newsletter of the
Amateur Telescope Makers of Boston
Including the Bond Astronomical Club
Established in 1934
In the Interest of Telescope Making & Using

Vol. 22, No. 11 December 2010

This Month's Meeting…

Thursday, December 9th, 2010 at 8:00 PM
Phillips Auditorium
Harvard-Smithsonian Center for Astrophysics
Parking at the CfA is allowed for the duration of the meeting.

Discovering Near-Earth Asteroids

Over the past couple of decades it has been established that asteroid and comet impacts have changed the course of evolution on the planet Earth. This revelation has resulted in great interest in discovering/cataloging the population of potential Earth impacting asteroids, and has made asteroid impacts a feature of the popular press and Hollywood movies.

The Lincoln Near-Earth Asteroid Research (LINEAR) program, operated by MIT Lincoln Laboratory under NASA and Air Force sponsorship, has contributed significantly to the discovery of asteroids and comets and to the knowledge of the asteroid population in the solar system. The LINEAR search technology and search results will be described along with the current estimated impact risk to the Earth.
Our speaker, Dr. Grant H. Stokes, is Head of the Aerospace Division of MIT Lincoln Laboratory, responsible for the Laboratory's programs in space control and electro-optical systems and technology. In that capacity, Dr. Stokes supervised the demonstration and transition of the first space-based space-surveillance system to Air Force operations and has initiated programs to develop next-generation technology for establishing Space Situation Awareness. These programs include the Space Surveillance Telescope, which will provide a 3.5-meter aperture prototype ground-based space surveillance search system, and a program to upgrade the Haystack Radar to W-band operations, yielding high resolution radar images of satellites.

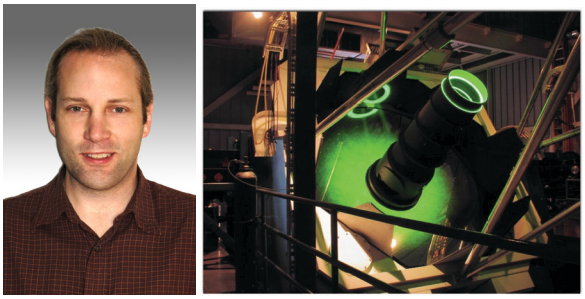
Dr. Stokes was recently a member of the Air Force Scientific Advisory Board (SAB). In that capacity, he was the Chairman of the 2006 SAB Summer Study on Space Survivability. In addition, he chaired the 2006 Science and Technology Review of the VS Directorate of Air Force Research Laboratory and the 2007 review of the Air Force Office of Scientific Research (AFOSR). Dr. Stokes was honored with the Air Force Meritorious Civilian Service Award for his four years of service to the Air Force Science Advisory Board.

Dr. Stokes directs the development and operations of the Lincoln Near-Earth Asteroid Research program, which, as part of the NASA/Space Command partnership, has become the world's premiere asteroid search capability, finding ~50% of the near-Earth asteroids discovered since 1998. Dr. Stokes holds a Ph.D. degree in physics from Princeton University and is a member of the International Astronomical Union.

~ Bernie Kosicki, President ~

November Meeting Minutes . . .

Lecture: "Einstein, the Moon, and the Long-lost Soviet Lunar Rover: Testing Gravity with Lasers to the Moon"



Images courtesy Tom Murphy

The November meeting (828th) of the Amateur Telescope Makers of Boston featured Professor Tom Murphy of the University of California, San Diego and project leader of APOLLO (Apache Point Observatory Lunar Laser-ranging Operation). Laser range measurements between the Earth and the Moon have provided one of our best tests to date of General Relativity and gravitational phenomenology. APOLLO is now collecting range measurements at the unprecedented precision of one millimeter, which has produced order-of-magnitude improvements in a variety of gravitational tests. Tom discussed how lunar ranging works, evidence for degradation of the reflectors, finding the lost Soviet Lunokhod 1 reflector, project status and science outlook.

Tom studied physics at Georgia Tech, and pursued graduate work at Caltech. There he built an infrared integral field spectrograph for the Palomar 200-inch telescope, using it to study mergers between large gas-rich ultra-luminous infrared galaxies. As a post-doctoral researcher at the University of Washington, Murphy began design and construction of an apparatus to test gravity by bouncing laser pulses off the reflectors left on the lunar surface by American astronauts and Soviet rovers. Since 2003, Tom has been at the University of California, San Diego.

Einstein and Relativity

Special Relativity answers the question, "if travelling at the speed of light, do your headlights work?" Einstein explored the consequences of the answer and indicated that they would. In the math, worked out by him and others (Lorentz), the inevitable conclusion is that space and time are mixed together as inseparable "spacetime."

It has long been known that different objects fall at the same rate. This suggests a mass "equivalence." Inertia, how hard a mass is to move is equal to how attractive the mass is to gravity. Einstein's key insight, General Relativity, mass tells spacetime how to curve and curves in spacetime tell a mass how to move. Gravity is therefore a geometrical property of space and time, which is why all objects respond to it in the same way. Einstein determined the equation $G\mu\nu=8\pi T\mu\nu$. He knew about the anomaly in Mercury's orbit (recognized in 1859) and calculated it using General Relativity. Additional experimental evidence was obtained by Sir Eddington in 1919, by observations of starlight deflection on the limb of the Sun during an eclipse. Einstein's prediction that time runs slower in gravity was confirmed in 1960, now measured to extreme precision, and required for our GPS navigation systems to function. In 1917, he applied his theory to the universe and determined that it would not permit a steady-state. He added a cosmological constant to allow this. In 1929, Hubble announced observed expansion of the universe leading to Einstein calling the fudge factor his biggest blunder.

Testing General Relativity: APOLLO

"Is the shape of the Moon's orbit consistent with the predictions of General Relativity?" If the equivalence principal is true, the Sun's gravity pulls equally on the Earth and the Moon. Therefore the Earth's orbit and the Moon's average orbit follow the same path. Calculations indicate a difference from Newtonian gravity by more than 10 meters. How can this be measured?

Equipment: Telescope – 3.5m Apache Point Observatory at 9000 feet which offers a larger collecting area and a 1 arcsecond pointing accuracy compared to other current Lunar Laser-Ranging systems and able to operate at full moon and during daylight. Laser – Nd:YAG laser operating at a wave-length of 532 nm. This laser has a pulse-width of 120 ps, a pulse energy of 115 mJ, and a repetition rate of 20 Hz (3.1×10^{17} photons per pulse). The laser is expanded to fill the 3.5 m aperture of the APO telescope. In this way, the very high peak power (in the GW range) does not harm the telescope mirror coatings, and presents less of an eye hazard to curious pilots. What would this look like from the Moon? A -4 mag green light on Earth's night side (full earth is -17 mag). Detector – Lincoln Labs 4x4 array avalanche photodiodes 30μm diameter at 100μm spacing with lenslets oversampled gated on for 100ns around expected pulse return time. Timing – GPS-slaved clock with 100MHz frequency reference with digital time resolution of 25ps and system control timing resolution of 10ns. A corner reflector on the telescope samples the outgoing pulses to calibrate laser start times. Given system parameters, typically 1000 photons are required for a 1mm statistical error however 50% of pulses return 1-10 detected photons.

Ranging issues to overcome: Measuring gravitational centers (not surface), Earth rotation, lunar orbit and libration, solar orbit of Earth and Moon, Earth's surface fluctuation due to tides, atmospheric pressure, surface water, earthquakes, etc.

Signal issues: Lunar return signal (19^{th} mag) vs. Lunar surface (-13 mag) or a 10^{13} contrast ratio. Filtering domains to improve this: Spectral – 1nm bandpass, Spatial – 2 square arcseconds, Temporal – detector on for 100ns every 50ms leading to a10^{16} total background suppression giving a signal to noise ratio of 10^3. Loss issues: only one in 10^{18} photons completes the journey. Analogy: if each photon was represented by a grain of sand 1mm on a side, they launch a cubic kilometer of sand (1000km of beach, 100m wide, 10m deep) to get one grain back.

Pointing Accuracy: 1 arcsecond beam-width requires 1 arcsecond pointing accuracy while the Moon is moving at 15 arcseconds/sec. and the distance is changing at up to 400m/s.

Timing accuracy: Single photon detectors are only on for 100ns around the time return photons are expected. Prediction time can change by >100ns between shots. Light moves 100 feet in 100ns, a bullet only the width of a hair. 50 pulses in flight at any given time. Precision barometry for atmospheric delay (.2 mbar). Tight feedback between data collection and analysis.

Positional Accuracy: Precision GPS to .5mm horizontal, 2.5mm vertical. Gravimetry used to determine platform location to .1mm to account for up to 520mm changes due to lunar and solar tides influence on the Earth's crust as well as loading from atmosphere, ocean and ground water, even earthquakes and dome rotation.

Reflector degradation: 10% return is now nominal, 1% at full moon. Dust build up could explain the overall deficit as well as thermal effects causing the additional divergence of the exit beam when heated by sunlight at the full moon. Note: Thermal effect and response time will be tested during the lunar eclipse on Dec. 20^{th}.

Laser divergence: 532nm laser starting at 3.5m from the source, 2km at Moon, 10-15km back at Earth.

Records broken: APOLLO has achieved record photon rates by a factor of 70 better than the previous best. Typical nightly precision is 1.5mm. Full moon ranging is back. Size, shape and orientation of reflectors have can be verified. Sub-millimeter (.8mm) ranging has been achieved with 6624 photons in 5000 shots.

The Hunt for Lunokhod 1 (L1):
This lunar rover was delivered to the lunar surface on Nov. 17^{th}, 1970 and included a 14 element reflector. It roved 10.5km over 11 lunar days, stopping for the lunar nights with the reflector aimed at Earth. The Russians knew the movements and had surface images, but without high resolution imaging, they could only guess exactly where the crater field was. Trying to find it in a survey fashion would be like trying to find a needle in a haystack. Due to system performance constraints, the field of view is only 2km by 20m at the L1 position. The initial search area was a 5km radius. This would take ages to search. The Lunar

Reconnaissance Orbiter (June 2009) instrument package including a high-res camera, laser altimeter and corner cube array allowed location of the lander to within 100m accuracy and altimetry narrowed it down even further to within 5 meters radius. On April 22, 2010, a signal was observed 270ns from prediction and verified. Further observations have narrowed the location of the reflector to within 1cm. The returns from L1 are even better than from its twin L2 and are usable in lunar daylight. L1 is the reflector closest to the visible edge of the Moon so it is the most sensitive to lunar orientation. It is key for understanding the lunar interior, gravity tests, and tidal deformation.

Tom concluded by indicating how privileged he was to be involved in Basic Science Research. Exploration in basic science has lead to unforeseen advances. Who knows what will come from it in the future?

Comments from questions: APOLLO improves previous ranging accuracy by a factor of 10. Based on an observed 10cm deformation of the Moon surface, we can infer interior structure based on torque – there is a liquid core. The Moon is moving out at 3.8cm a year. Accuracy includes modeling the mount, down to including 3mm of thermal expansion over the year. The axis intersection is considered the telescope location since it does not move relative to the system components. There are multiple safety factors in place while the laser is being fired, including lookouts, coordinated firing times, and aircraft tracking. There were questions about adaptive optics for the laser and the practicality of placing an active laser on the Moon. Additional references:

http://www-physics.ucsd.edu/~tmurphy/apollo/apollo.html

http://www-physics.ucsd.edu/~tmurphy/apollo/doc/matera.pdf

http://www-conf.slac.stanford.edu/ssi/2007/talks/Murphy_080907.pdf

http://cddis.gsfc.nasa.gov/lw16/docs/presentations/llr_2_Murphy.pdf

http://cddis.gsfc.nasa.gov/lw15/docs/presents/Friday0900.pdf

http://lunar.colorado.edu/publicfiles/tiny/files/lunokhod-1-elm.pdf

November ATMoB Business Meeting:

Bruce Tinkler provided the Secretary Report.

Nanette Benoit provided the Treasurer's Report. The yearly reports have been filed. The auditor is experiencing delays. Nanette reminded everyone to submit expenses in a timely way. This helps make the club accounting look better financially.

Tom McDonagh provided the Membership Report. He thanked any veterans and anyone who have served in the armed forces for their service. Membership renewals are almost on track. Renewal deadline is Dec. 1st.

Bruce Berger provided the Observing Committee Report. Work is being done on telescope problems. The observing program is under development.

John Reed provided the Clubhouse Report. During the last work party the 10' dome was assembled in order to improve its form and get it in shape for the winter. The clapboards on the north side of the house were painted, making the house look good from the street (important to MIT). The old machine shop work continued and the snow fence was put up. He announced that the next work party would be November 20th. The 20" has been updated for better eyepiece use. There has been some good observing. He suggested seeing the newsletter for all the details. Bruce Berger added that working on the dome was done to prevent and undo deformity caused by previous storage. Also, there was a mouse problem in the conduit including damage to wires. This has been repaired and functionality restored to the C14. Measures have been taken to prevent this from happening again.

• Fridays, Nov 5-Dec 3 New perspectives on the Solar System, Clubhouse
• Nov 12 – Last day for the Great WW Star Count –Starcount.org
• Nov 13 – New Member Orientation Night, Clubhouse
• Nov 20 – Clubhouse Work Party #12

Star Parties
• Nov 12 King - Amigo School Star Party, Cambridge
• Dec 6 Swallow Union School, Dunstable
• Dec 8 Banneker School Star Party (ITEAMs), Cambridge

Bernie announced that Bernie Volz is in Australia to check the Eclipse site and that the group will rent busses to access an inland site in case of need. Bernie announced that Mario Motto has been confirmed as Vice President of the AAVSO. Mario is also organizing a monograph of the health effects of light pollution which will be endorsed by the AMA. This is being put together by 3 of the biggest researchers in the area, contributing over 100 papers in peer reviewed journals. This will be used in presentations to congress and local governments and to the lighting industry. Refreshments were provided by Neil Fleming.

~ Bruce Tinkler, Secretary ~

Clubhouse Report . . .

The weather held for the November 20, 2010 work party- 40° sunny conditions allowed outside projects to continue:

Three members worked through the morning to finish the Home Dome assembly now ready for winter weather.

The 17" hutch was thoroughly cleaned of debris. The 50mm finder near the eyepiece was supplemented with the 80mm finder mounted on the rocker box assembly to allow ground sightings of the sky object viewed from the ladder. All optics were collimated. Please do not change any collimation set screws. The

system is ready for viewing. Steve C., Sai V., Dick K., George P., and Dave W. worked this effort.

The clamshell observatory roller spacers were replaced and adjusted to assure smooth opening/closing. The 8" mount drive electronics were extensively tested and further work areas identified. Dave P., John B., Al T., John M., George P., Phil R., worked this effort.

The new telescope room table was modified to fit the available space, materials removed, wall cabinet primed and painted, wood work priming completed. John B., Dave W., Eric J., and John R. worked this effort. Previously on Nov. 13 the old wood work was cleaned and primed late in the day by John R. and Art S. Subsequently on Nov 23 the trim final painting was completed, second coat applied to the wall cabinet, and remaining walls repaired by Art S. and John R.

The far barn East doors, previously screwed together, are now operable with the installation of three gate hooks inside, to secure this end of the barn from the elements. This will allow storage of either mowers or blowers with easy egress summer or winter. John R., Nina C., and Dave W. worked this effort.

Temperatures were too cool to finish painting the North house wall, however a session on Nov 13 with 60deg temperatures allowed the bottom third to receive a second coat while the middle third was scraped and primed along 2/3 the length. The remaining wall awaits the next 60° day. Art S. and John R. worked this effort.

Grass growth was not sufficient for tractor mowing, however hand mowing lowered the cut to allow easier shoveling should we receive early snowfall. Mike H., Dave W., and John M. worked this effort.

Solar scopes set up early by John B. and late afternoon by Phil R. gave good solar viewing.

The last burger and dog and salad lunch of the season was prepared by Sai V. and Eric J. and enjoyed by a hungry crew.

Work left over from this session was tackled by Art S. and John R. in a six hour effort Nov 23. Four 30 gallon bags of empty containers and trash was picked up and removed. All old paint cans were removed. Equipment pieces were boxed and stored in the barn loft metal cabinet. Painting implements were packaged and similarly stored. The lawn folding chairs are also stored in the barn loft. Two new fire extinguishers were found to be expired without use. Flammable material was removed from the kitchen stove proximity. The Evaporator room is now ready for floor repair; however several pieces of the bell jar lift tubing were not found and are critical for reassembly-help is needed in locating these pieces. All first level floors were swept, vacuumed, and polishing floor triple wet washed. Sink tubs were scrubbed free of dirt. We may be ready for the New Years Eve party, if we can keep the house clean and neat. At least Thursday night mirror grinding, the Friday night Astro class, and Saturday night observing have a cleaner environment.

Thanks to J. Blomquist, S. Clougherty, N. Craven, M. Hill, E. Johansson, D. Koolish, J. Maher, G. Paquin, D. Prowten, J. Reed, A. Swedlow, A. Takeda, S. Vallabha, for donating their day to our clubhouse work session. We were joined by Henry Hopkinson and John Small(on Saturday night duty) who hosted new member Bill Robinson. Several members continued processing their astrophotos into the wee hours. The next work party is December 18 starting at 10AM. Come join us.

~ Clubhouse Committee Directors ~
~ John Reed, Steve Clougherty and Dave Prowten ~

Clubhouse Saturday Schedule

December 4	Clougherty	Takeda
December 11	Jacobson	Johansson
December 18	Cicchetti	Reed
December 25	**CLOSED** Christmas Day	
January 8	Cicchetti	Reed
January 15	Jacobson	Johansson
January 22	Maerz	Meurer
January 29	Evans	Lumenello

Thoreau on Astronomy . . .

On Ponkawtasset, since, with such delay,
Down this still stream we took our meadowy way,
A poet wise has settled, whose fine ray
Doth faintly shine on Concord's twilight day.

Like those first stars, whose silver beams on high,
shining more brightly as the day goes by,
Most travellers cannot at first descry,
But eyes that wont to range the evening sky,

And know Celestial lights, do plainly see,
And gladly hail them, numbering two or three;
For lore that's deep must deeply studied be,
As from deep wells men read star-poetry.

These stars are never pal'd, though out of sight,
But like the sun they shine forever bright;
Aye, they are suns, though earth must in its flight
Put out its eyes that it may see their light.

Who would negelect the least celestial sound,
Or faintest light that falls on earthly ground,
If he could know it one day would be found
That star in Cygnus whither we are bound,
And pale our sun with heavenly radiance round?

A Week on the Concord and Merrimack Rivers, 1849

~ Submitted by Tom Calderwood ~

Membership Report . . .

Membership count as of 11/27/2010 is at 255 individuals
Same time last year: 295

The deadline for membership renewal is December 1st. Please send along your payment now. If you require a renewal form feel free to contact me @ 617-966-5221.

The renewal process can be completed on-line using Paypal. No Paypal account is required. Follow the link below to renew now.
http://www.atmob.org/members/person.php?frid=renewals

Renewal checks may also be mailed:
ATMoB
c/o Tom McDonagh
48 Mohawk Drive
Acton, MA 01720

Don't delay, renew today!

The Amateur Telescope Makers of Boston, Inc. is a 501(c)3 organization. Donations are gladly accepted and are tax deductible to the fullest extent allowed by law. Consider making a tax-deductible contribution to the club during your estate and tax planning this year. Many companies make matching contributions at an employee's request. This is a simple way to make your donation go twice as far.

Please take the time to seek out and welcome our new and returning club members:

Bill Robinson
Jim & Charlie Gettys
Mark Schiefsky
Joshua Ashenberg
Julio Vannini
Leonard Matula

~ Tom McDonagh, Membership Secretary ~

Sky Objects of the Month . . .

Sky Object of the Month – December 2010
NGC 457 (the "ET Cluster")

Have you seen "ET" lately? Not that cute little alien in Steven Spielberg's 1982 movie. I'm referring to the ET-mimicking open star cluster NGC 457 in Cassiopeia. Discovered by William Herschel in 1787, NGC 457 is often overlooked because of its proximity to the Messier cluster M103. That's an unfortunate situation. Not only is NGC 457 superior to M103 in visual appearance, it may well be the most spectacular of Cassiopeia's clusters. As such, it's a must-see for late-autumn star parties.

And it does bear a striking resemblance to Spielberg's ET. Two bright stars, phi1 and phi2 (φ1 and φ2) Cassiopeiae, are ET's eyes. A group of some 40 stars northwest of the "eyes" form ET's body. Passing through the body is a row of stars that extends outward to the sides, creating the alien's arms. Add a handful of stars to the base of the body, and ET has feet. Because phi1 is brighter than phi2, ET seems to be winking at us.

ET will greet the owner of even the most modest telescope. A standard 2.4-inch refractor can capture a few dozen cluster members, while an 8-inch reflector will snare one hundred. A magnification of just 50-75X comfortably encompasses the cluster's 20 arc-minute width.

To find the NGC 457, trace a line from epsilon (ε) to delta (δ) Cassiopeiae, then extend it about two degrees beyond. Although the cluster's published magnitude is 6.4, the presence within the cluster of 5th magnitude psi1 betrays the presence of NGC 457 to the unaided eye.

Is phi1 Cas a true member of NGC 457? Various distance measurements would indicate otherwise. While phi1 appears to be around 2000 light years away, studies place the main cluster at a distance of nearly 10,000 light years. However the distance estimates of NGC 457 are sketchy at best and one set of measures puts phi1 squarely within the bounds of the cluster. But let's not quibble about statistics. Instead, train your telescope on NGC 457 and say hello to ET.

Your comments on this column are welcome. E-mail me at gchaple@hotmail.com.

~ Submitted by Glenn Chaple~

2011 RASC Observer's Handbook . . .

26 copies of the 2011 RASC *Observer's Handbook* were ordered and received. I will be selling them at the December 9th club meeting. Any left over copies will be available at the January meeting. Handbooks will be $20 each, with about $2.50 of that amount going to the club.

The guide is published annually by The Royal Astronomical Society of Canada (RASC). Regarded as an excellent reference for data on the sky, the first handbook was published in1907, making this its 103rd year of publication. The 2011 guide has 360 pages. The 24-page section called "The Sky Month By Month" has an extensive listing of events for each month of the year. See http://www.rasc.ca/handbook for more details.

~ Submitted by Eileen Myers~

New Year's Eve Party . . .

Al Takeda, Art Swedlow, Eileen Myers, John Reed, and Sai Vallabha will again host the New Year's Eve Party at the ATMoB Clubhouse! Festivities on Friday, December 31st will start at 6:30 pm and will go on past midnight. Please come and bring friends, family, a telescope, and something tasty to share!

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January *Star Fields* DEADLINE
Noon, Sunday, December 19
Email articles to the newsletter editor at newsletter@atmob.org
Articles from members are always welcome.

POSTMASTER NOTE: First Class Postage

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Virginia Renehan starparty@atmob.org

How to Find Us...
Web Page www.atmob.org

MEETINGS: Held the second Thursday of each month (September to July) at 8:00PM in the Phillips Auditorium, Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge MA. For INCLEMENT WEATHER CANCELLATION listen to WBZ (1030 AM)

CLUBHOUSE: Latitude 42° 36.5' N Longitude 71° 29.8' W

The Tom Britton Clubhouse is open every Saturday from 7 p.m. to late evening. It is the white farmhouse on the grounds of MIT's Haystack Observatory in Westford, MA. Take Rt. 3 North from Rt. 128 or Rt. 495 to Exit 33 and proceed West on Rt. 40 for five miles. Turn right at the MIT Lincoln Lab, Haystack Observatory at the Groton town line. Proceed to the farmhouse on left side of the road. Clubhouse attendance varies with the weather. It is wise to call in advance: (978) 692-8708.

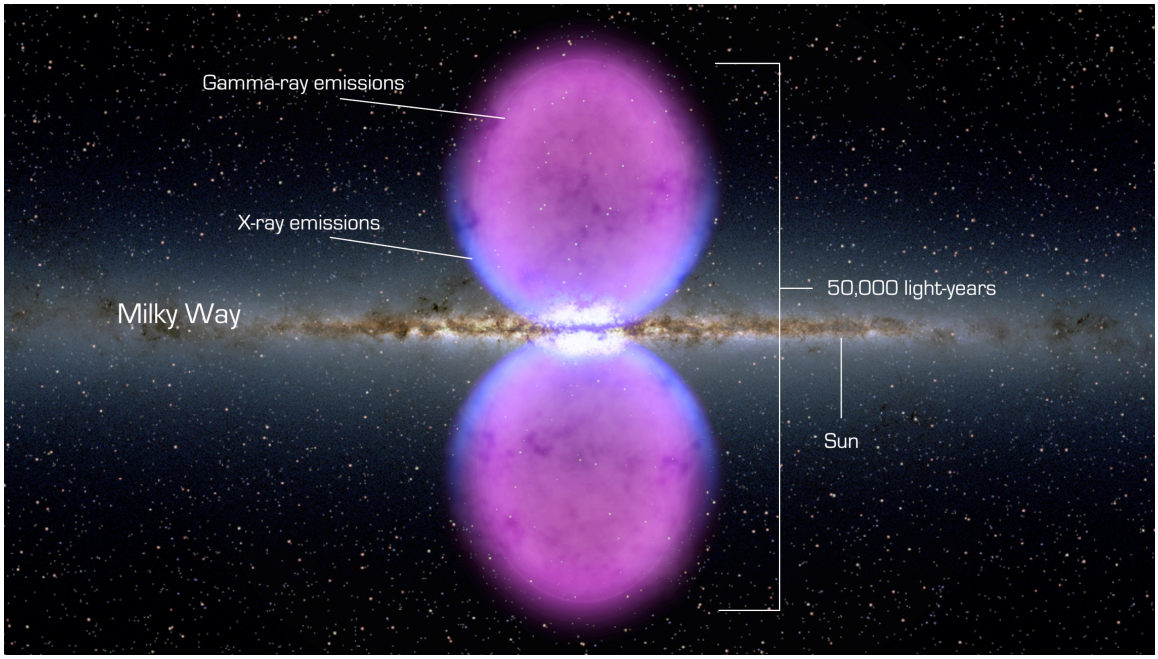
New Year's Eve Party at the ATMoB Clubhouse

WHERE CAN YOU GO to celebrate First Night 2011 with your family and friends and not have to drop a bundle of money? The Tom Britton Clubhouse in Westford of course! Festivities on Friday, December 31st will start at 6:30 pm and will go on past midnight. You can arrive at any time. The opportunity to shout "Happy New Year" will be every hour on the hour, starting with the Greenwich New Year's and continuing with each time zone through Eastern Daylight Time. Please come and join the fun and bring your family and friends. Bring something tasty to share. Entrée type dishes and hors d'oeuvres would be very welcome. Folks will be arriving and leaving all evening. There will be plenty of non-alcoholic beverages. The clubhouse will be warm, and with Moonrise at 4:45 a.m. Saturday morning, your favorite stars and galaxies will be attending, so bring your telescope. Joining us too will be the start of the Quadrantids meteor shower (radiant in Boötes), named after the obsolete constellation Quadrans Muralis. The forecast looks good (ok, so it is a bit early to know) and the party is on regardless of the weather. Don't forget your warm observing clothes and boots. We will also have indoor games, quizzes, songs, and PRIZES so do join us to welcome in 2011 together. Any questions, email Eileen at starleen@charter.net or 978-461-1454 (day) or 978-456-3937 (evening).

Co-Hosts, Clubhouse Committee Members Al Takeda, Dr. Art Swedlow, Eileen Myers, John Reed and Sai Vallabha

President's Message.

This past month, the NASA Fermi Gamma-ray Space Telescope imaged a new and mysterious structure - two huge areas of gamma ray emissions, which look like two large bubbles touching at a point near the galactic center. The diameter of each bubble is about 25,000 light years- about the distance of the Solar System from the center of the galaxy. Where did these energy sources come from? How long have they been there? Astrophysicists don't have a good answer at this time.



NASA Picture

As astronomers, we shouldn't be surprised when there are unexpected new discoveries in our universe, since scientists don't even understand what most of the universe is made of. In our November meeting, Professor Tom Murphy reminded us that dark matter and dark energy represent more than 95% of the universe, while the "normal" energy and mass we can see and measure- what the general public knows as the entire universe- only amounts to 5%. Physicists have been trying to understand dark matter for over 75 years- so far without much success.

Near the end of the nineteenth century, satisfied that the theory of electricity and magnetism theory had been successfully formulated, so Lord Kelvin, president of the Royal Society, probably felt safe in pronouncing "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement." We all know now that his prediction was somewhat premature. In the next few decades, along came special relativity and quantum mechanics, followed closely by general relativity. These developments were completely unanticipated and thoroughly upset the conventional wisdom of the time.

Unlike the situation that our Royal Society physicist foresaw, we know that science is far from being cleaned up. There are lots of questions bubbling in the pot, for example, the need for a unified field theory that joins quantum mechanics and general relativity, the explanation of why gravity is such a weak force, understanding of dark energy and dark matter, and the list goes on. To get a handle on these questions, we are making more and more elaborate equipment to tell us more about fundamental physics of the universe- it will be an exciting time for those interested in these questions. So, when something unexpected is discovered (like these new gamma ray bubbles), we know that science is marching forward and even more wondrous discoveries lie ahead.

Keep looking forward,

Bernie Kosicki