RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers

(SARA)

June/July 2007

Journal Contents

Expanded Electronic Version

Administrative Pages...….2
Jeff and Cynthia Lichtman……...……...……...…….3
President's Page……..……..……..……...….4
From the Editor's Desk……..…….……..…….5
SARA 2007 Post Conference Review……..……..…6
Talk Summaries/Photos, Meeting Reports, Elections, New Board Member Profiles
Star Quest IV……...…….....17
Jupiter & The Jansky Antenna ……19
NRAO 40-Ft Radio Telescope Experiments……..…….……21
Solar Radio Astronomy Miscellany……..31
Sun Art to Sunspots
Welcome New Members ….……33
Radio Astronomy Resources .....……...……...…34

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~ Congratulations to Our Founder and His Wife ~

This piece of good news escaped announcement in the last journal issue (because Jeff had kept this a secret until he announced it in mid June!): Jeff Lichtman and Cynthia Herod, the lovely North Texas University business graduate, pilot and diver, were married on April 28, 2007. They currently live in Hollywood, FL. The membership joins me in wishing you both a sweet and long-lasting life showered with many blessings.

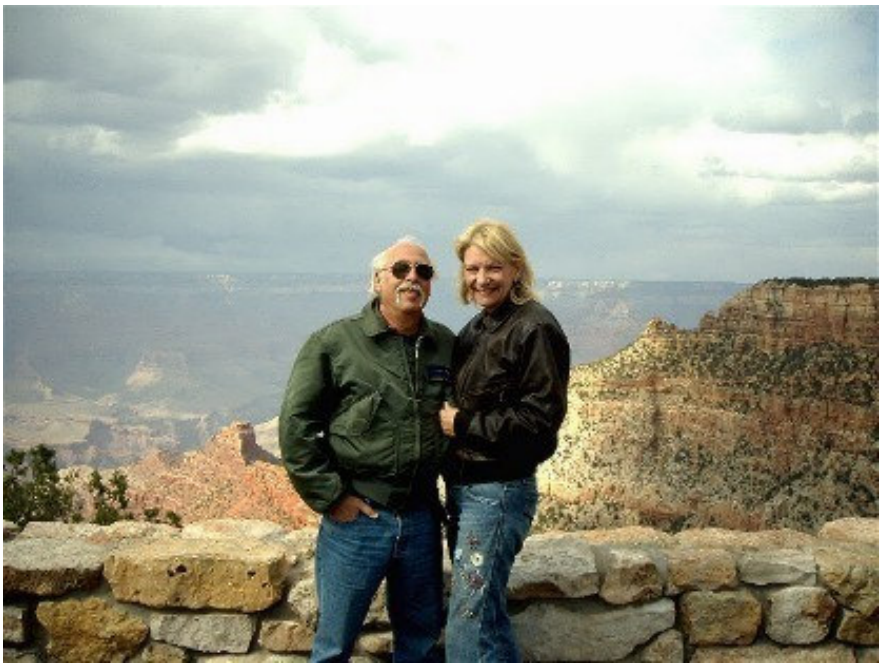


Figure 1: Jeff and Cynthia on their honeymoon at the Grand Canyon, AZ

~ The President's Page ~

Unfortunate family business took precedence over the SARA conference for me. After a short illness and hospitalization, my mother passed away during the conference. Paul Shuch and the other officers stepped in and didn't miss a beat keeping the conference on track. John Mannone has provided a summary of events and election results in this issue. Thanks for all your support.

Charles Osborne
SARA President

As Editor of the journal, I am sure I speak for the SARA membership who extends its condolences to the passing of Charles' mother on July 2, 2007. May our prayers and thoughtful wishes be extended to his family and especially to his father who is also ill.

The 2007 SARA Conference 2007 was held at NRAO in Green Bank, WV from Sunday, July 1 through Tuesday, July 3 with a modest attendance of 42 of the 47 registered guests.

The 4th annual Green Bank Star Quest star party immediately followed the conference for the remainder of the week, July 4-7 [http://www.greenbankstarquest.org/]. A precedent has been set. It is likely that the 2008 SARA Conference will immediately precede Star Quest V. NRAO official confirmation is pending the tentative dates (Sunday June 29 to Wednesday morning July 2, 2008). This will mean the possibility of a family vacation and more time on the 40-foot.

Though the Hermitage was closed for renovations, the Boyer motel and campground, as well as bunkhouse lodging at Green Bank, supplemented the dormitory arrangements.

New and old members should be interested in filling out the ***Interactive Questionnaire*** concerning your areas of interest [http://radio-astronomy.org/admin/survey.htm].

On July 17, our Treasurer, Tom Crowley, announced that *PayPal* is now available for new SARA membership as well as for our convenience for such things as renewal of membership. Just go to the membership page at [http://www.radio-astronomy.org/]. Remember, our Treasurer's new approach concerning membership renewal dates greatly simplifies the logistics of database management; i.e., everyone's membership is due to expire immediately before the conference.

John C. Mannone for Charles Osborne K4CSO

~ From the Editor's Desk ~

The pre-conference issue of *Radio Astronomy* (April/May 2007) was well received at least by those providing verbal feedback. So that I can better serve the membership, please give me feedback (as well as contributions to the journal). If you liked it, tell me why. If you did not like it, then even more so tell me why. Also, write me and ask what topics you would like to see in future issues. I encourage all work (email blurbs to academic papers; hands-on project tips to analytical tools; etc.). Submission Guidelines are posted on the SARA website: [http://radio-astronomy.org/publicat/authjrnl.htm].

***

The SARA journal is available to members in print form for a modest increase in dues. However, the costs of postage, printing and handling have been absorbed by the rest of the membership. Recent postage rate increases have aggravated this expense even more. Therefore, for those receiving print issues, the Board voted to increase dues to $30 effective June 2008; however, those receiving just electronic versions will continue to pay $20 per year. So that most of the membership does not have to continue subsidizing the excessive costs for those receiving print journals, *Radio Astronomy* will eventually be available only as an electronic journal. June 2009 is the target. Members will enjoy fast delivery, full-color issues, length not limited by printing/postage costs, and major savings for the club (around $500 - $1000 for each issue), which can be used for scholarships and projects. *This electronic issue is 33 pages, but the postal issue is limited to 24 pages.*

***

In this issue, you will find the 2007 SARA Conference debriefing: cameos of the talks, perhaps an anecdote or two, together with figures and photos; business meeting report summaries; and election results. In addition, a brief report on the Green Bank Star Quest star party is included. Radio astronomy on the 40-foot dish is something that is an important part of the conference and SARA members look forward to this. Unfortunately, it was unavailable to SARA because some high school students had dedicated access to it. Nevertheless, for those of us who remained for the star party, the 40-footer was available for our own *Radio Quest*: radio spectra, Doppler shifts of hydrogen gas clouds, mapping the Milky Way, and reviving the Jansky antenna to tune-in Jupiter storms.

I must repeat what I said in the last issue— *The sun continues to be a fascinating object of wonder.* This issue features items from *Sun Art* to S*unspots*.

Now, for my usual shameless plug, please visit my website for an interesting blend of astronomy —the art and science— for innovated outreach ideas. *Adventures in Astronomy* is found at [http://home.earthlink.net/~jcmannone/].

John C. Mannone, Editor

~ SARA 2007 Post-Conference Review ~



Figure 2: SARA 2007 Conference Photograph by the NRAO Green Bank Science Center (photo credit Paul Shuch).

I. Presentations

Editor's Selected Summaries and Commentary

Radio Frequency Interference (RFI)

The keynote talk, "Present and Future Radio Spectrum Trends: their impact on radio astronomy," by Dr. Andrew Clegg, W4JE, from the National Science Foundation, was an informative presentation. He highlighted the vagaries of radio frequency noise pollution and elucidated the complex relationships among various regulatory organizations, like the conflicted agencies of the Federal Communication Commission (FCC) and the National Telecommunication and Information Association (NTIA), which is under the Department of Commerce. Dr. Clegg kindly distributed full-color frequency allocation charts depicting protected slivers of radio astronomy, mostly in the submillimeter bands. You can download a 2003 version from the NRAO site, but be aware that the allocations are volatile and changes are made by the time the newest chart is printed. It will be in our best interest as amateur radio astronomers to register our facilities with permanent radio telescopes (even the small 7-footers). Then market researches can see your use of *bone*

fide radio frequencies so that they will consider this before their clients install potentially bad RFI-producing equipment in your vicinity.

On a follow-up with related materials, David E. Fields (representing a large East TN effort and several authors), addressed "Our Neglected Natural Resources: Conservation of Dark Skies and Radio Spectrum Space." Tamke-Allan Observatory (TAO) folks have been very proactive in working with local politicians in establishing lighting ordinances to protect the dark skies around the observatory. The thrust of the talk was in our treating the optical night sky, as well as the radio sky, as natural resources, which provide much more than the simple pleasure of observing and learning about our universe.

(I later learned that NRAO has developed an RFI kit to be loaned to amateur astronomers to help educate the public via museum programs and other educational outreach efforts. The participating kit users will also collect data at their location so that an RFI map for the country can be produced analogous to the one for light pollution— perhaps like those on "The Night Sky in the World: Satellite Monitoring of the Artificial Night Sky Brightness and the Stellar" [http://www.lightpollution.it/dmsp/]. Though a clear sky clock, [http://www.cleardarksky.com/csk/], was mentioned as the desired analogous product for radio astronomy, I agree with Charles Osborne that some kind of energy density measure is more appropriate. For in radio astronomy, the upper frequencies are often the cleanest, but the energy levels fall off for most targets of interest. Something like a map showing maximum usable frequency is interesting, but still might not be suitable, [http://www.spacew.com/www/realtime.php]. However, one should contact Sue Ann Heatherly for more information.)

In a recent e-mail, Charles Osborne expounds, "One narrow, but strong, spurious noise can contaminate an observation, but it is easier to remove than a lower broad RF digital noise spurious. If one is doing spectral line work, it is far easier than wideband multi-GHz bandwidth work (as NRAO often does). That necessitates lots of purity in a wide swath of spectrum. Often, Doppler shifts chase the signal out of protected assignments down into heavily used commercial frequencies.

NRAO, being in the middle of nowhere makes for the most protection, yet satellites can even contaminate the middle of nowhere. So some day an observatory on the far side of the Moon may be the best NRAO location. For amateurs, knowledge is power, knowing what is natural vs. man-made noise is crucial."

It is most noteworthy that the International Dark-Sky Association has a webpage dedicated to radio-light pollution, [http://www.darksky.org/resources/links/radioast.html].

Educational Outreach



In the exploits of an amateur radio astronomer, Jon Wallace shared his high school and community outreach techniques in two talks ("How to Present to a General Audience Group" and "Solar and VLF Observing"). The audience gets a basic science lesson with many audiovisual aids and demonstrations with kits or experiments designed by Jon. He is willing to share his presentation and encourages you to share ideas for astronomy outreach.

During the IBT Panel Discussion, we were all encouraged to start preparations now for the International Year of Astronomy in 2009 [http://www.astronomy2009.org/] (I recommend downloading their attractive brochure). The microwave antenna has had a resounding public appeal and we should include it to increase radio astronomy awareness effectively. (After all, even the professionals do not insist on the distinction of being an optical, radio, or x-ray astronomer. We are in a "multi-wavelength" era of astronomy.) Four more "Itty Bitty Telescopes" found homes and Navigators.

Dr. Paul Shuch is not only an exceptional engineering professor and speaker, but also a very entertaining musician/song writer. We were treated to one of his songs on radio frequency bands, which does make learning them easier. Some samples of his talent are found here, [http://www.setileague.org/drseti/what/songs.htm].

Astrochemistry

Chemists Bruce Lerner and Bill Marshall enlightened us on some basic cosmic chemistry. Bruce laid down some foundations of basic chemistry ("Astro-chemistry - A Review of the Contributions of Radio Astronomy") and told us why fragile organic molecules exist in the harsh environments of electron-stripping UV and x-ray fluxes. Molecular clouds actually provide some central shielding. In addition, much of the chemistry seems to be occurring inside dust grains. The NASA Ames Research Center website [http://www.astrochem.org/] has some basic science as well as current Astrochemistry news.



Bill Marshall has also done some interesting work proposing that carbides could react to form amino acids ("Carbides if Present in Stellar Dust and Origin-of-Life Precursors"). Bill proposed the model years ago as an alternative to the classic Miller-Urey electric discharge experiment, and has gained renewed interest in recent years. Amino acids have been formed in the laboratory from CaC_2, which is reactive with water to form acetylene. This subsequently can react with NH_3, CO_2, and H_2O; all found in

molecular clouds, to yield amino acids, albeit a mixture of both chiralities. (It is noteworthy that only left-handed stereo isomers prevail in terrestrial life.) NRAO has some excellent posters showing how shocks can promote exotic reactions in space, [http://www.nrao.edu/imagegallery/php/level2a.php?subclass=Astrochemistry&class=Miscellaneous].

Computer Related Talks

Perhaps the most distant travelers to the conference this year are Jasim Mutlaq (Kuwait National Radio Observatory) and a fellow Kuwait Astronomy Club member, Meshal Al Mashan. Jasim, a computer scientist, presented "Scheduling, Automation, and Control in Astronomical Instrumentation." He carefully explained the differences among some of the desired attributes in software development: scalability, expandability, and modularity. Jasim introduced the XML-based framework— instrument-neutral-distributed-interface (INDI). This may prove to be quite useful even for amateur radio telescope projects because of its powerful protocol for distributed control systems, especially to put our telescopes on line. The extra good news is that it is a free platform, [http://indi.sf.net/].



Figure 3: Jasim Mutlaq and David Fields in the historic Drake Lounge engaged in telescope control strategies.

Another software talk was slated, "A Year of Gnu Radio and SDR Astronomy: Experience, Practice and Observations," but regrettably, Marcus Leech and David Ocame were not able to attend the conference.

Construction Projects

The presentation entitled "Construction of an Integrated Observation Network: Challenges, Progress and Observations," showed great promise. Tyler Moore, a student researcher, had progressed nicely on the Tamke-Allan Solar Observation Network.

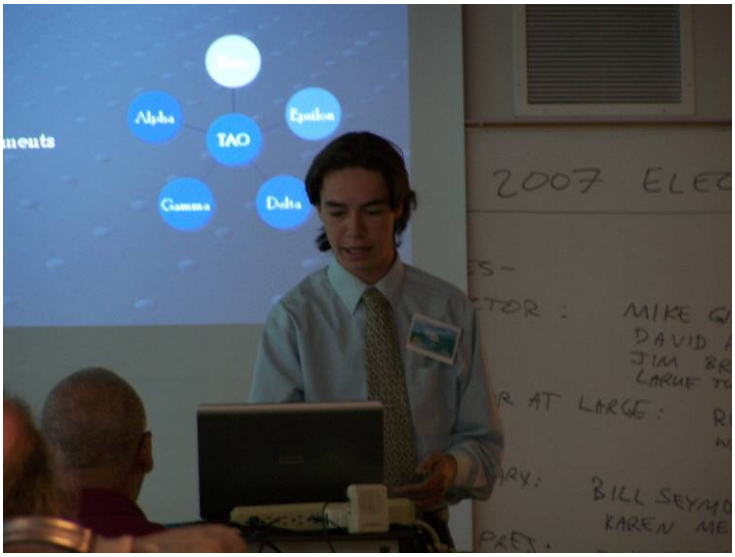


Figure 4: Tyler Moore is shown presenting his network of radio telescopes.

Most notable was the design and implementation of a deployable field unit— a waterproof box to house electronics, including a Cat 5 connection for real-time display of the radio antenna signals on the internet. Of course, the remote sensing antennas were established, too. These range from 20 MHz Radio Jove dipole systems to 1420 MHz parabolic dishes. SARA had awarded some funding for the project in 2006.

Paul Oxley, a Microwave Engineer, described his challenges in "Designing a Tunable LO for ELF Measurements." The L-band Local Oscillator (LO), operating between 950 to 1450 MHz, will be part of a project to digitally process solar ELF signals. Rodney Howe has been corroborating with Paul on his project. I anticipate exciting results.

Rodney is also volunteering at the Deep Space Exploration Society (DSES) in Longmont, CO. The facility has two 18-meter, fully steerable dish antennas. The Society's director, Dr. Jamie Riggs, presented a talk, "Radio Astronomy at Colorado's Table Mountain." Her group's revitalization effort will eventually lead to a functioning interferometer. The telescopes have been inoperative since 1980 before the Society took over the administration of the facility. Other organizations besides DSES, such as local university groups, are interested in using these dishes for their work. Their varied interests include radio receiver theory, satellite downlink service, edge-of-space balloon telemetry, and astronomy. With this amount of interest in the use of these two dishes, the question Riggs poses is "how is DSES making them ready and available?" It seems to me that they will get it done. A photograph of the attractive antennas appears on the website: [http://www.deep-space.org/]. You can join their Society, contribute your talent and partake in an excellent opportunity to do radio astronomy with these 59-foot antennas. Shad, a San Diego SARA member who had just joined them, is already busy writing software for the telescope.

Jamie Riggs' expertise is in statistics. A great deal of discussion and excitement is in its application to search strategies for extraterrestrial intelligence. Protracted discussions have recently appeared on the SARA listserve. This was precipitated by Paul Shuch's talk (see below) and David Fields' proposal of a related model; both involve Bayesian statistics. Therefore, the brief review in the following reference might be helpful: "A Bayesian Mathematical Statistics Primer" (Jose M. Bernardo, Universitat de Val`encia, Spain, 2006). The six-page PDF is available at the following site, [http://www.uv.es/~bernardo/2006Bahia.pdf]. Sage advice is reflected by one of Jamie's operating dictums, the null hypothesis, which can be stated as follows: *every outcome is random unless proven otherwise*.

Bayesian Statistics

Dr. Paul Shuch (SARA VP, who is also with the SETI League, Inc.) raises some ethical questions in his talk, "Shouting in the Jungle: the SETI Transmission Debate." Search efforts in the last 50 years have failed to disclose radio signals from extraterrestrial intelligence, if they had been transmitted. Whether they have or have not, does suggest a change in contact strategy. Paul queries, "might it not be time to break our radio silence, and make some noise from planet Earth? What are the risks, and the benefits, of transmitting into interstellar space? What does international law say about the subject? Just how detectable is Earth's radio footprint, anyway?"

As pointed out above, this indeed has spurred some discussion (over a dozen pages). Here is part of that (slightly modified and updated from a July 4 entry on the SARA listserve). Dr. David Fields posits,

"Can you imagine that it might be practicable to state the probability whether a data stream (from a SETI or SARA measurement) contains interesting/meaningful data patterns? Might a scale of possible information content be proposed (*TAO scale or index*) just as the one we now have for possible exposure/risk associated with an off-planet transmission (*San Marino scale*)?

Like the San Marino scale, the TAO scale might have parametric components (e.g., signal/noise ratio) and non-parametric components (judgment-based). I like components to be multiplicative as in the Frank Drake Equation, rather than additive. A first cut might be this:

$$TAO\ scale = \frac{S}{N} \times T \times U \times C \times D \times P$$

Where the parameters are defined as follows:

-*S/N* is the normalized signal/noise ratio ranging from 0 to 1.
-*T* is a measure of low signal threshold (sensitivity of the antenna/feed/receiver system), quantifying the concept that one is more likely to make discoveries at the boundaries of exploration rather than in the "well-farmed" central regions.

-*U* is informational uniqueness, based on the source, ranging from 0 (explained), to 0.5 (possibly easily explicable), to 1.0 (unusual/unknown).
-*C* is signal content, a statistical measure of a probable pattern (obvious, derived, or heuristic).
-*D* is signal duration (fraction of an hour, but with lower limit set to include pulse events, thus ranging from 0.1 to 1.0).
-*P* is the signal periodicity (0.5 for unknown to 1.0 for sidereal periodicity)."

A cursory examination with the *Google* search engine yielded many interesting peer-reviewed articles concerning Bayesian statistics and the search for extraterrestrial life, e.g., "Atmospheric Biomarkers" (Cowan, 2005) addresses *Bayesian Statistics and the Perils of False Positives*. The search for extraterrestrial life should begin with a search for oxygen, [http://www.astro.washington.edu/cowan/school/biomarkers.pdf].

Research

Heather Fries, another student associated with the Tamke-Allan Observatory, cleverly displays neutral hydrogen (HI) regions on 3D-physical models. Data obtained with a 7-foot dish and a spectrometer (*Sprectracyber*) scanning the 21-cm line of hydrogen was plotted on a celestial sphere. The Doppler shifted HI-regions are color-coded and their coordinates marked on the transparent celestial sphere, which was fashioned from a clear and colorless 2-foot "beach ball." Her PowerPoint presentation is called "A Celestial Plot of HI Regions and Other Radio Sources."



Figure 5: Heather's "HI-Radio Atlas" is poised next to the radio telescope used to acquire the data at TAO.

Another research topic, "Gamma Ray Bursts and Amateur Radio Astronomy," was presented by your editor. Despite the catastrophic computer crash about a month before the conference, the presentation was reconstructed in part. The concomitant loss of literally hundreds of hours of data analysis directed the talk to a somewhat more theoretical review of GRBs. One of the most significant parts of the presentation was the analysis of x-ray data for the magnetar SGR-1806-20 superflare (December 27, 2004). Of course, the talk concluded with a poetic composition, *Nightshade*, a sobering poem on the potentially fatalistic effects of a GRB event directed too close to Earth.

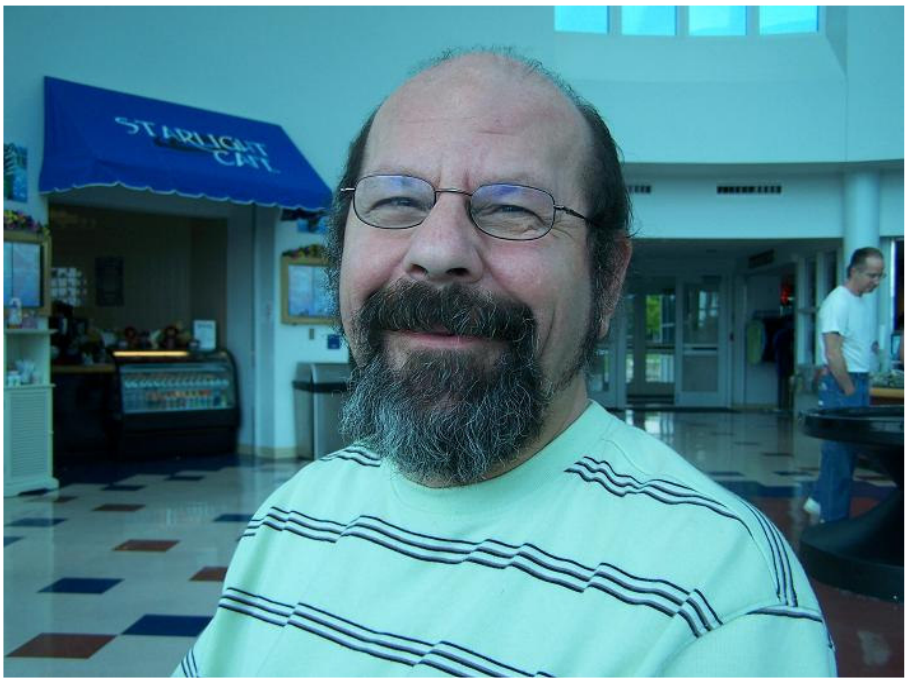


Figure 6: Professor Mannone delighting in the Visitor Center at NRAO Green Bank, WV (*picture credit* Heather Fries).

II. Proceedings

You are encouraged to purchase a copy of the Proceedings to this year's conference, as well as last year's 25th Anniversary Conference of the Society of Amateur Radio Astronomers, to get the "rest of the story" beyond the anecdotes and summaries presented above. They are available through the SETI Store linked from the SARA website, in particular, find them at the following addresses:

2006 Proceedings— [http://www.setileague.org/seticon/sara2006.htm]
2007 Proceedings— [http://www.setileague.org/seticon/sara2007.htm]

III. Business Meeting Summary

Follow the "Administrative Information" link on our website [http://www.radio-astronomy.org/] to read the meeting's minutes.

IV. Election Results

The updated Board consisting of Officers, Directors, and Appointees is reflected on the administrative pages of this journal as well as on our website (see link trail above). Some of the races were reportedly close according to Hal Braschwitz, who acted as the official "balloter." A summary of these races follows: (1) Incumbent, Paul Shuch prevailed against contender Paul Oxley, for the Vice Presidency. (2) Hal Braschwitz yielded as Secretary and Karen Mehlmauer defeated Bill Seymour for the position. (3) Gordon Meldrum acquiesced as Director; that left three slots and four contenders, the incumbents David Fields and Jim Brown were re-elected to continue for another term, LaRue Turner won the third slot (Mike Gingell was the other contender). And (4) Wanda Diaz was defeated by Rodney Howe as Director at Large. Next year, there will be a Door Prize Chairman, soon to be appointed by our Vice President. Congratulations to the new Board members and to those completing their terms.

V. New Board Member Profiles

In the future, I plan to profile the other Board members, but for now, welcome these new folks: Secretary Karen Mehlmauer, Director LaRue Turner, and Director at Large Rodney Howe.

Karen writes:

"I have had a life long interest in astronomy that started when I first read the celestial navigation books my Dad used as a Navy pilot in WWII. In college, I majored in Earth & Space Science (after briefly toying with Chemistry) and went on for a M.Ed. in Secondary Science with a specialization in Planetarium Operation and Management. I

was the Graduate Assistant at the D. D. Pierce Planetarium at Clarion University and while there, I helped many thundering herds of elementary children identify the constellations during live presentations. I then spent a couple of years as the Education Director for the Hansen Planetarium in Salt Lake City, UT until marriage moved me to St. Louis where I did free lance work for the planetarium there. When I moved back to Salt Lake, I entered the wild world of public education and spent 17 years teaching Astronomy, Geology, and Biology at West High in downtown Salt Lake City. I also taught their Science Focus course for Gifted and Talented 7th graders who had been accelerated into the high school. Now they were a challenge! Since returning to my home town of Beaver, PA in 2000, I have, among other things, partnered with an old friend to start a new Internet business. [My] current hobby [is] renovating a 60+ year old cottage. I look forward to taking an active role in the SARA organization and will gladly continue to expend my time and effort to share with others the joy I find in the wonders of the night sky."



Figure 7: Karen at Green Bank for the 2007 Conference (*photo credit* Jim Brown).

LaRue writes:

"After teaching at the college level for many years, sandwiched between other employment, I am currently teaching secondary math in Ohio. Additionally, I have worked as an electronic engineer, computer network administrator and telecommunication director.

Radio astronomy brings together the disciplines I love. I hope to help SARA increase its outreach programs to young adults and interest others in hope of sharing this wonderful science."



Figure 8: Larue in his Ohio home

Rodney tells us:

“Born in Tarrytown New York, 1948. Built my first *Heathkit* shortwave radio when I was 10. Moved to Colorado in 1963 to ride horses. Got a Bachelors degree in secondary teaching, English and Math in 1976. Went back to school to learn computers, and have been programming in FORTRAN since 1980. Got a Masters degree in GIS and Remote Sensing from CSU in 1997. The last 20 years: I've been building databases and geo-spatial animal disease models for the USDA.

For a hobby I went back to building radios in 1997, doing VLF, and Radio Jove listening. Then after a couple visits to Green Bank in 2000 and 2001 for SARA conferences, I have been working my way up the frequency bands: 20.1MHz to 406.7MHz to 1.420GHz to 1.665GHz and now I am looking at 11.7GHz and 12.2GHz with Paul Oxley's ELF solar radio. All along the way, I have been studying astrophysics to understand the signals we see. I have been a SARA mentor for the last 6 or 7 years helping get college-age folks interested in astronomy: Hamdi Mani, Brian Kloppenborg, Niaome Piquette have been a few.”

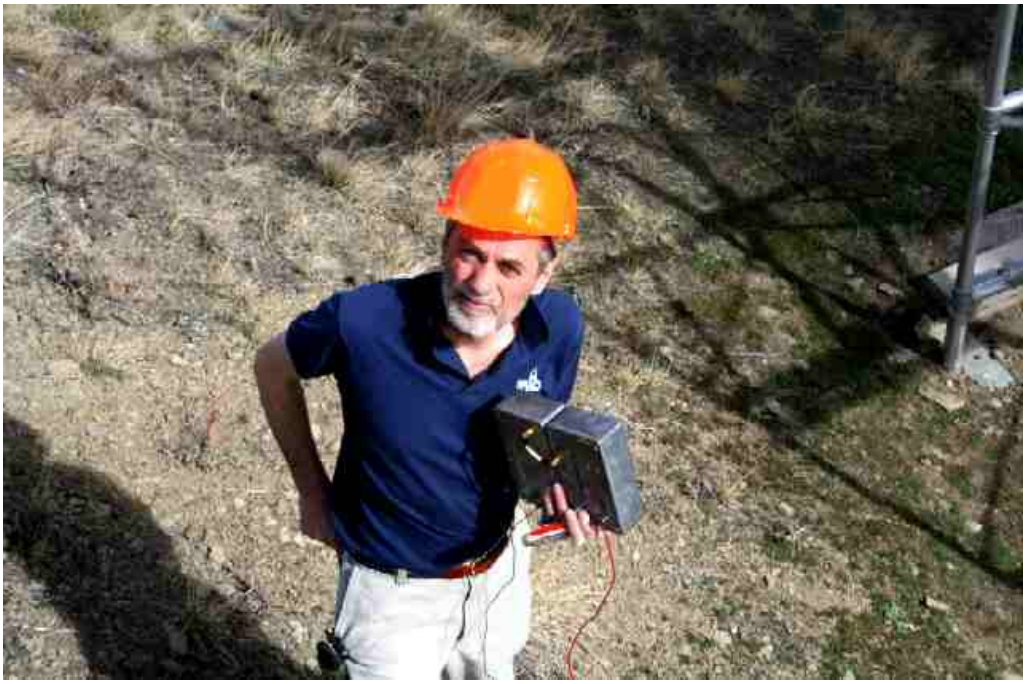


Figure 9: Rodney at one of the twin telescopes at the Deep Space Exploration Society facility on Table Mountain. The 1665 MHz to 70 MHz downconverter (loaned by Carl Lyster) is being prepared for installation at the feed of the lower dish.

~ Green Bank Star Quest Star Party ~

The star party is mentioned here since there is a major effort to schedule the SARA Conference immediately before this event in future years. Starquest also actively promotes radio astronomy. Sue Ann Heatherly presented several talks on the "Introduction to Radio Astronomy" and our very own Tom Crowley gave several daily workshops on the 40-footer as well as being there to help us collect data for the midnight runs when the Milky Way "spoked" its way through the southern meridian. One night we stayed until well after three am collecting galactic data (see the Radio Telescope Experiments below). Of course, the IBT was promoted as well as Radio Jove. In fact, a group of amateur astronomers enthusiastic about radio astronomy participated in Jim Thieman's coordinated viewing for the anticipated Jovian storms on Thursday/Friday (11:30-3:00 am EDT).

This year we enjoyed clear skies on Friday and Saturday. Some who were not accustomed to light pollution-free skies were fooled by what they thought were invading clouds when actually the Milky Way was spilling stars. Besides good views of the gas giants, Jupiter and Saturn, the skies were graced with Venus. On both nights, meteors showered the Green Bank tapestry of radio ornaments, presumably the delta Aquarids. A huge fireball cannoned the Saturday night sky, I suppose in response to the fireworks celebration still lighting the southern horizon.

Plan to come next year and hear a cadre of great talks and see some great skies (though there is a good share of clouds, fog and rain this time of year- think of it as an opportunity to do radio astronomy when its cloudy). The coordinators are working on getting a telecon set up with the ISS. Also, I might be one of the speakers next year and encouraged me to blend in radio astronomy, which I undoubtedly will. Tentatively, the SARA Conference will be from Sun June 29-Wed morning July 2, followed by Star Quest from Wed July 2-Sat July 5, 2008.



Why is it important to protect Radio Astronomy from pollution of the Radio Spectrum?

> *Because about sixty- five percent of our current knowledge of the universe has stemmed from radio astronomy alone. The discovery of quasars, pulsars, black holes, the 3K background from the "Big Bang" and the discovery of biochemical hydrogen/carbon molecules are all the result of professional radio astronomy.* (Found on the International Dark-Sky Association website referring to our SARA Web Site!)



Figure 10: Promotional Circular for the 4th Annual Star Party at Green Bank: amateur radio astronomers were among the record number of attendees to Star Quest

~ The Jansky Antenna ~

As mentioned above, Radio Jove conducted a coordinated viewing during the star party since the Jupiter/Io interaction favored magnetic storms. Though no recordings were made, the full-scale functional model of the Jansky antenna (the original shown in the photograph was stolen in the 1950s near Bell Labs) was connected to an ICOM receiver, which reportedly detected some decametric emission after 2:00 am. The connection was made through a cable in the Drake Lounge (which SARA members Jim Brown, Charles Osborne, and others had worked on during the previous year). A brief history of the famous antenna is noted here. Later in the night, folks with Radio Jove systems captured some of the Io-Jupiter storms [http://jovearchive.gsfc.nasa.gov/].

The first radio antenna used to identify an astronomical radio source was one built by Karl Guthe Jansky, an engineer with Bell Telephone Laboratories in Holmdel, NJ. In 1928, he investigated “short waves” (wavelengths of about 10-20 meters) for transatlantic radiotelephone service. Jansky was tasked with finding sources generating static, which might interfere with radiotelephone service. Jansky designed the antenna to receive short wave radio signals at 14.6 meters (20.5 MHz). It spanned approximately 100 ft. and stood 20 ft. tall. He mounted the antenna on a turntable ("Jansky's merry-go-round"), i.e., on a set of four Ford Model-T tires, allowing him to monitor any direction. A small shed to the side of the antenna housed an analog pen-and-paper recording system. After recording signals from all directions for several months, Jansky eventually categorized them into three types of static: nearby thunderstorms, distant thunderstorms, and a faint steady hiss of unknown origin. In 1932, Jansky determined that the "faint hiss" repeated every day, but with a four-minute lag; i.e., a sidereal day associated with a reference to distant stars. Jansky compared his observations with optical astronomical charts and concluded that the radiation was coming from the Milky Way, with the strongest signals from the center the galaxy, in the constellation Sagittarius.

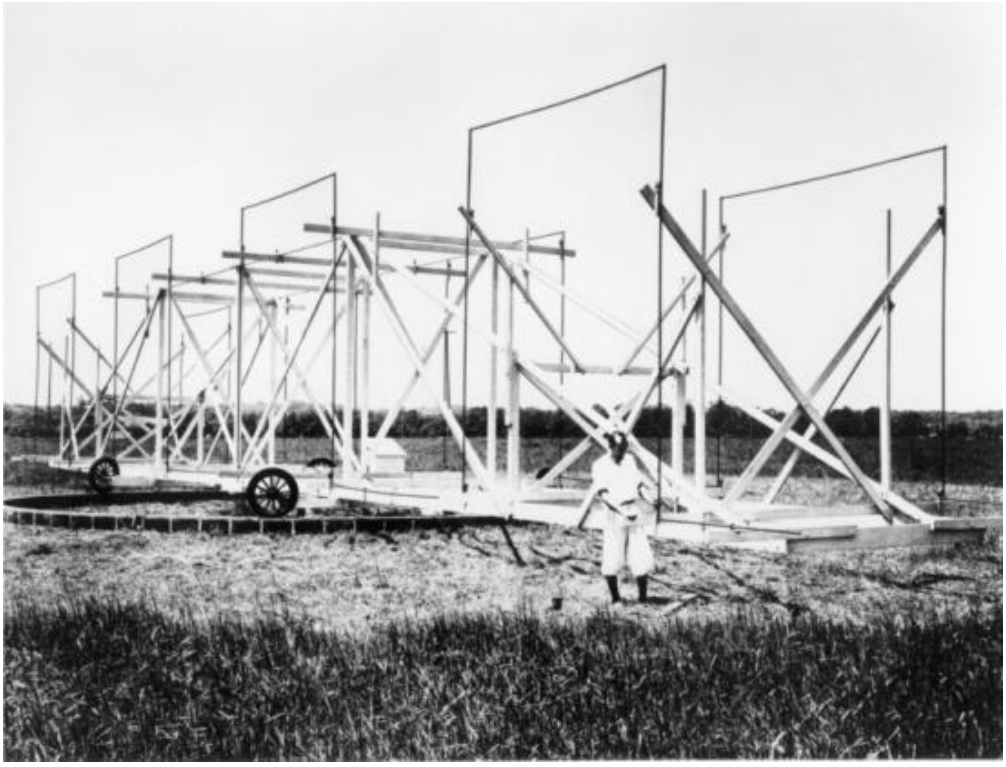


Figure 11: Jansky with his original antenna in New Jersey. (A full-scale model of the Jansky antenna is on the NRAO site in Green Bank, WV (near the entrance).

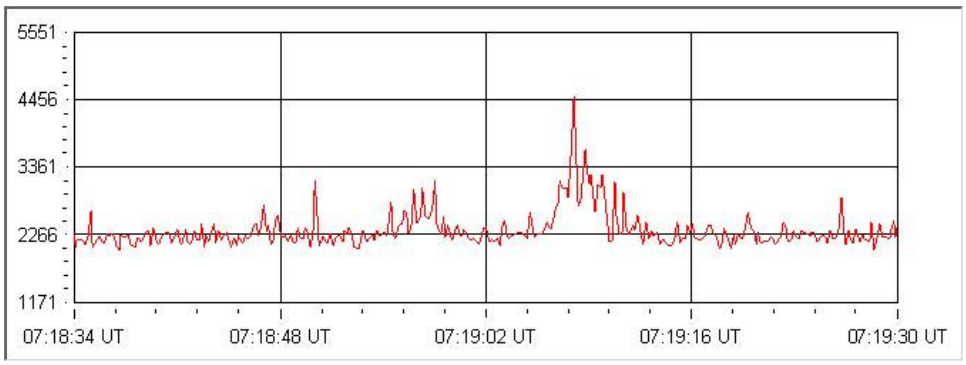


Figure 12: Io-C storm burst shortly after 3 am EDT 7/6/07 (Jim Sky, Hawaii)

~ NRAO 40-Foot Radio Telescope Experiments ~

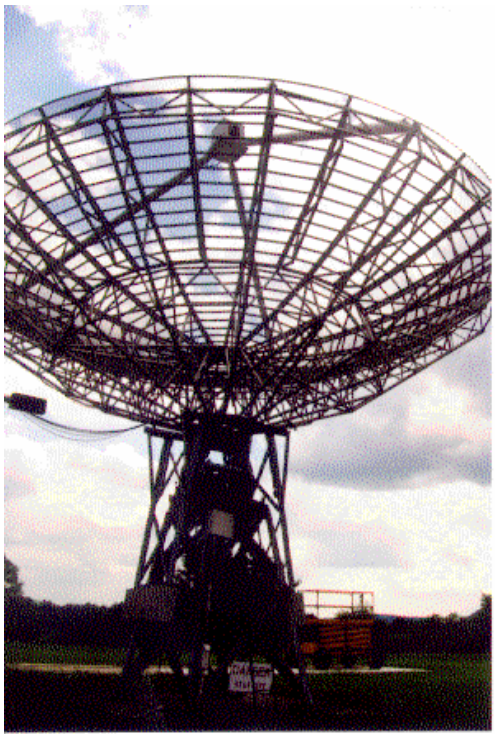


Figure 13: The 40-Footer at Green Bank, WV (p*hoto credit*: John C. Mannone, June 2002)

A major excitement for me at Green Bank is *doing* radio astronomy. The 40-foot radio telescope is the education workhorse for NRAO. It is often "booked" for experiments for high school and college groups, governor schools, teachers' workshops, star party groups, and of course, SARA. Unfortunately for *conferencees*, the telescope was not readily available; however, for those of us who remained for Star Quest, the nostalgic dish was once again available. The hallway walls in the visitor center are often lined with student projects. NRAO does a real good job of displaying their results; some with rather impressive contour maps for high school students. There is some data archived on the NRAO site for about ten targets [http://www.gb.nrao.edu/epo/40_data/]. The data is in ASCII format for easy importing to Excel or other spreadsheets. The radio flux of a target as it drifts through the southern meridian is recorded along with the right ascension (RA) and Declination (Dec). Though it is fun to analyze this data, there is no substitute for obtaining our own drift scan for exactly the same reason we can be captivated by seeing something gorgeous as M13 through an optical telescope for ourselves despite the exquisite Hubble Space Telescope images.

The electronic data acquisition has been inoperative for at least the last two years, but Tom Crowley will explore the possibility to get it back up within the year. Nevertheless, when analyzing the data the old-fashioned way, one would carefully coordinate the strip chart recorder with the antenna motion (declination motor), pen essential data on the charts, read numerous data points, record them, transfer the numbers to a spreadsheet, and reduce the data. This is a very time consuming process, but yields even more excitement when the final plots are generated.

I. Spectral Line Mode: Hydrogen Cloud Doppler Shift (Precursor to the Milky Way Galactic Rotation Curve)

In the last issue I had written, "Tom [Crowley] began showing folks how to measure the Doppler shift of neutral Hydrogen in the Milky Way. Perhaps your appetite can be

whetted to do something like this in July." And indeed mine was. Various teams of two or three folks practiced using the equipment as a spectrometer. At prescribed declinations, various pieces of the Milky Way traversed the one-degree beam width of the radio telescope ($\theta \sim \lambda/D$). Tom logged our findings. A metronome helped with a temporal rhythm that enabled a coordinated advancing of the local oscillator control knobs. With one second to the beat, 10 KHz clicks were marked-off on the running strip chart every two seconds— a two-man operation.

A parcel of neutral hydrogen may be moving away or towards the Earth-framed observer. The component of its velocity along our line of sight is the operative parameter that determines the (non-relativistic) Doppler shift; i.e., relative to Earth's inertial frame, the "radial" velocity is $v = c\ \Delta f/f_0$, where f_0 is the frequency of the 21-cm line in our rest frame (1421.406 MHz) and f is the shifted frequency. If $f > f_0$, it is blue shifted and apparently approaching us, if $f < f_0$, it is red-shifted and receding. (Note: we actually use the local oscillator frequency (LO = 110.50 MHz), which shows the same relative change. Alternatively, we can convert the shifted LO frequency to what we observe "in the sky."

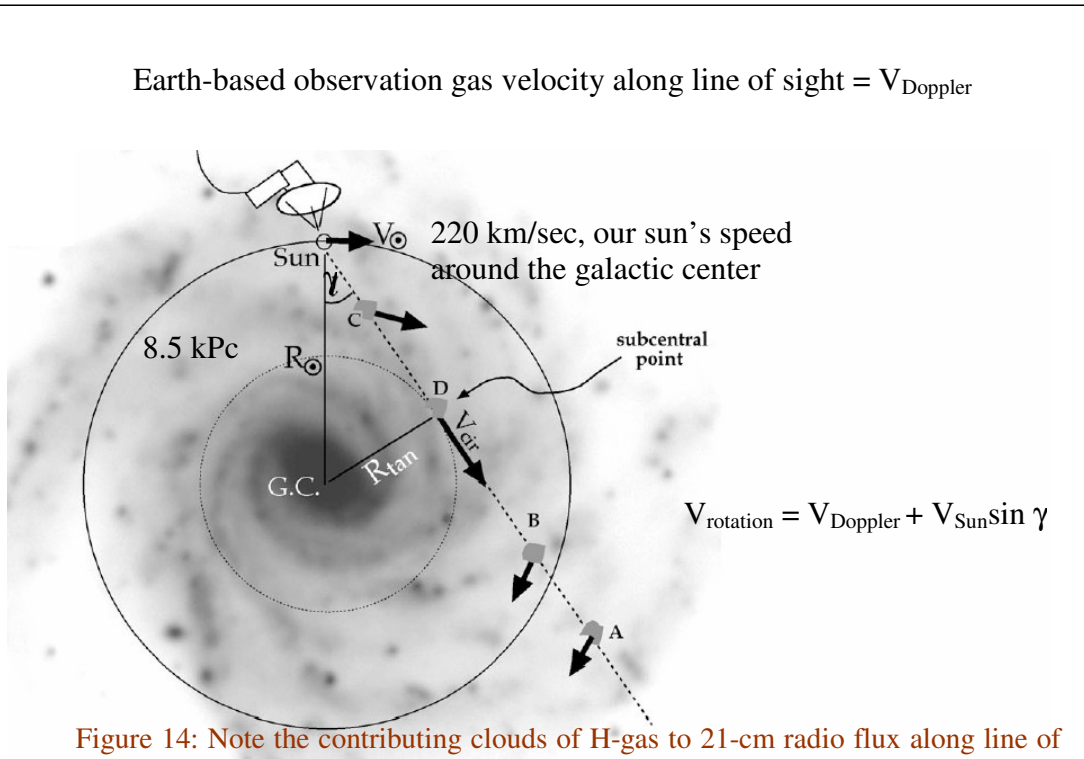


Figure 14: Note the contributing clouds of H-gas to 21-cm radio flux along line of sight at one galactic longitude. A total power measurement integrates over all this gas, but a spectral measurement segregates the clumps of gas according to their speeds.

Careful measurements in the galactic plane are needed to determine the galactic rotation curve. It shows how the rotational velocity of the gas varies with distance ($V_{rotation}$ vs. R_{tan}). It will be discussed in a later issue. Suffice it to say, that the nearly flat curve, first determined by Vera Ruben, strongly suggests the existence of dark matter. Dark matter is

a hot topic and this experiment should be pursued by more of us. This has a strong educational outreach potential (especially through astronomy clubs and public stargazes).

Some have already done this with small telescopes; for example, see *The Mystery of Dark Matter: The Galactic Rotation Curve for the Milky Way*, K. McGinty and D. Brotman, 2006 Summer Research Proceedings, PARI, June 2006: [http://www.pari.edu/audiences/teachers/pari-2006-summer-student-research-proceedings/summer-proceedings-document-4.pdf].

Nevertheless, some meaningful results are shown here from the collective data of several of us during Star Quest (Tom Crowley, Bill Seymour, John Mannone, and a couple others from a Greensboro, NC astronomy club stayed up until 3 am practicing on the 40-foot). As seen from our inertial frame, the line of sight parcels of neutral hydrogen will appear to approach us or recede from us at different galactic longitudes. First, the Doppler shift is measured and the velocity of the gas along our line of sight is calculated as above. Second, the equatorial coordinates are converted to galactic coordinates. This can be done graphically with the chart included in the operations manual of the 40-ft radio telescope. It is reproduced below and the raw data is plotted on it. As can be seen, most of the measurements fortuitously fall on or near the galactic plane. Third, considering only those data points, I correct the velocities for the contribution to the motion our sun, i.e.,

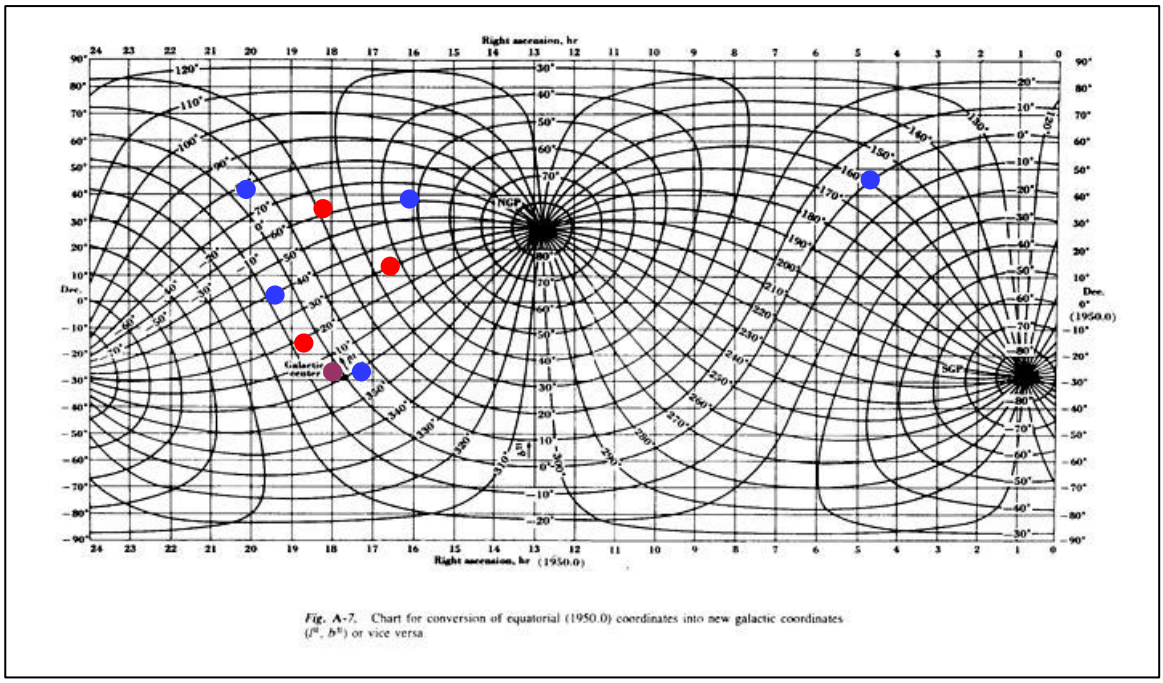


Fig. A-7. Chart for conversion of equatorial (1950.0) coordinates into new galactic coordinates (l^{II}, b^{II}) or vice versa.

Figure 15: Coordinate Transformation: Equatorial to Galactic Coordinates. Red dots are red shifted velocities, Blue dots are blue shifted velocities and the purple dot reflects no change. All but three or four are close to the galactic plane.

its component along the line of sight (V_{sun} sin γ). (Motion of Earth around the Sun was also included for this analysis. At 67,000 mph orbital speed, the correction can be as

much as +/- 30 km/sec.). Fourth, the velocity-longitude curve is generated, a 3rd degree polynomial fit is excellent and approximates a sinusoid. This result arises from the symmetry of the galactic rotation.

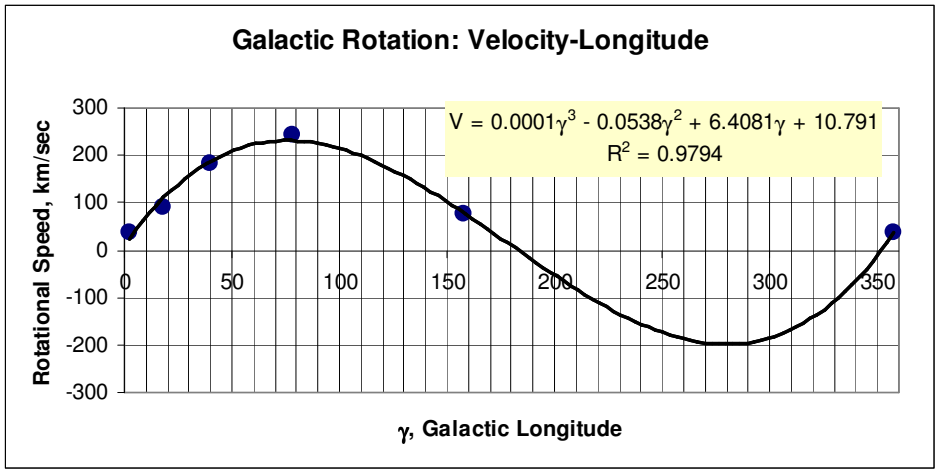


Figure 16: Doppler shifted gas velocities are corrected for solar and terrestrial motion and plotted against galactic longitude in the galactic plane (galactic latitude is zero).

II. Continuum Mode: Total Power— Mapping the Milky Way

Grote Reber continued the work of Karl Jansky and was the first to map the Milky Way in radio frequencies [http://www.nrao.edu/whatisra/hist_reber.shtml], followed by Kraus.

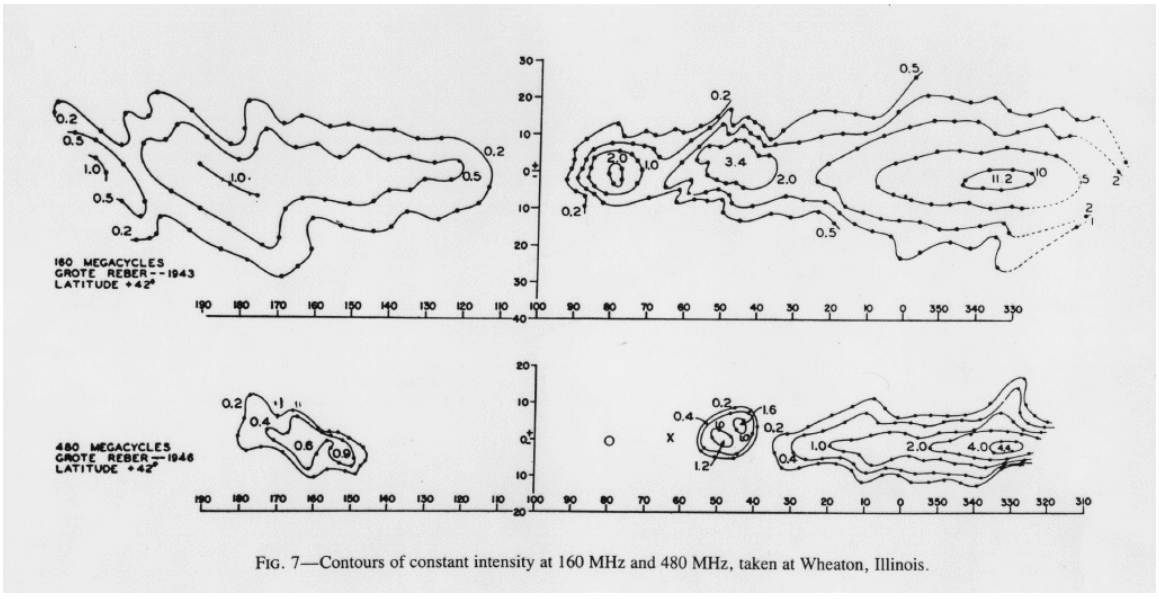
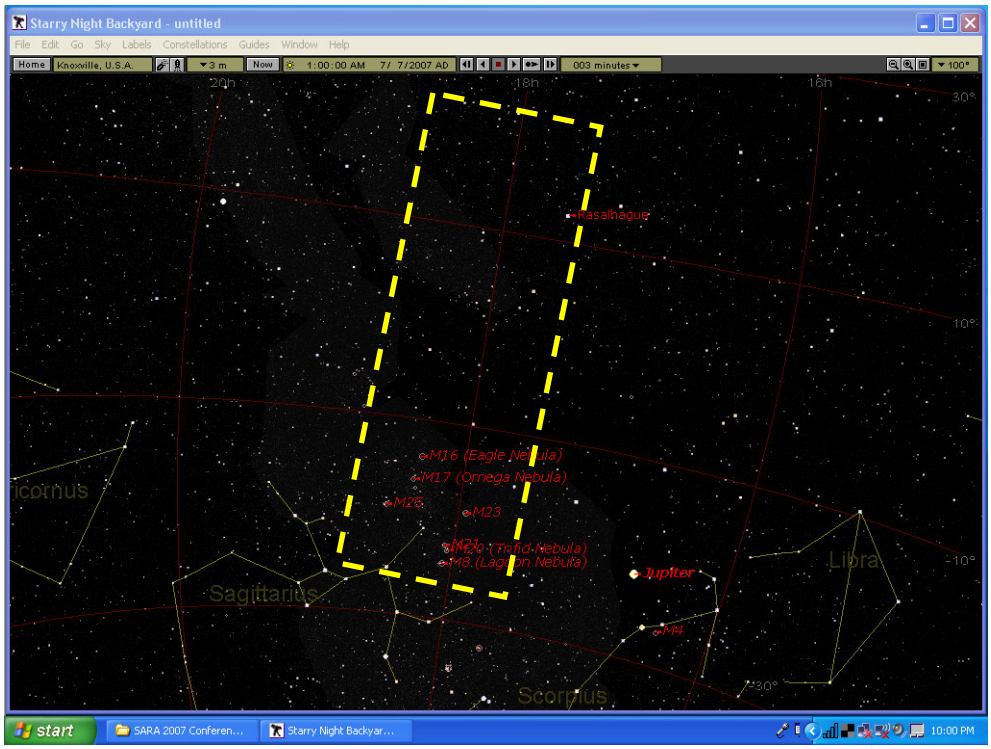


FIG. 7—Contours of constant intensity at 160 MHz and 480 MHz, taken at Wheaton, Illinois.

Figure 17: The contour diagrams are plotted in galactic coordinates in which the galactic equator runs horizontally. Most of the radio radiation is in or near the galactic equator. The vertical axes

are galactic latitude in degrees. The horizontal axes are galactic longitude, in which the direction toward the center of the galaxy has zero latitude (cited from Sky and Telescope, "Galactic Radio Waves," G. Reber, Vol.8, No.6, April, 1949).

There is a bit of nostalgia for me to reproduce the historical plot, albeit with different equipment and at a different frequency. In the last issue, I showed planetarium pictures of the Milky Way center favorably positioned over Green Bank, traversing its southern meridian around midnight. In the figures below, the piece of sky that was mapped in a preliminary experiment is depicted on planetarium software, as well as on Kraus' contour plot. The coordinates boxing the portion of Milky Way range +/- 20 degrees Declination (occasionally a bit more) and from 17:30 to 18:40 Right Ascension. This swath of sky was mapped using the following procedure (the additional challenge was to do it as a one-man operation):



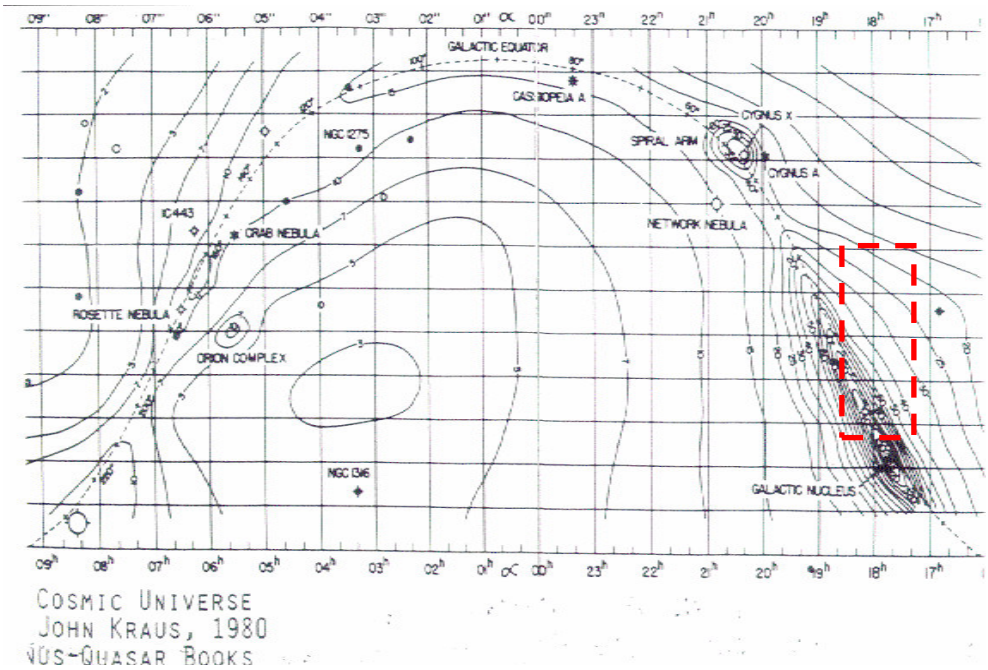


Figure 18: The approximate region of the of the Milky Way mapped after midnight July 6/7, 2007 with 40-foot radio telescope in continuum mode depicted (top) planetarium software (Starry Night Backyard, v.3.0) and on the contour map of radio flux (bottom) (*Cosmic Universe*, John Kraus, 1980).

Methodology

1) All the controls for continuum mode operation were set and the telescope pointed in the vicinity (and somewhat outside) of the starting declination of interest.

2) The console with the chart recorder (looks like a TV table painted gray) is moved closer to the telescope positioning motor control rack by carefully swiveling it so that both hands can simultaneously operate the individual devices such as recorder chart drive, chart marker, motor power and servo control.

3) A calibration is performed and repeated, at least once every 20-30 minutes.

4) The chart recorder is started (it may have been stopped to conserve paper).

5) The declination motor is started and quickly swung to full rate.

6) With left-hand fingers poised on chart marker switch, watch the clock-face dial of the declination position indicator (while also noting the local sidereal time (LST) on the computer terminal). As it passes the starting coordinate, say +20º (decreasing), actuate the chart marker. Be careful to avoid reading errors from parallax. Record the LST to the nearest second for each scan.

7) To study the characteristics of the declination motor, actuate the marker toggle switch every 10º increment (see the red and blue "tick" marks in Figure 19). Note: Do not plan to start a particular scan on the minute or on a specific chart graduation. The time lost in doing is not worth it, especially if the traverse is through a rapidly changing region.

8) Zigzag through the Declination angles as the Right Ascension progresses along the temporal axis of the strip chart. It will nominally take 3 minutes to traverse 40º swaths and be ready for the next one, first in one direction, then, in the other. It will be a busy time for one person; no opportunity to sit and rest, just relentless data-taking for over an hour.

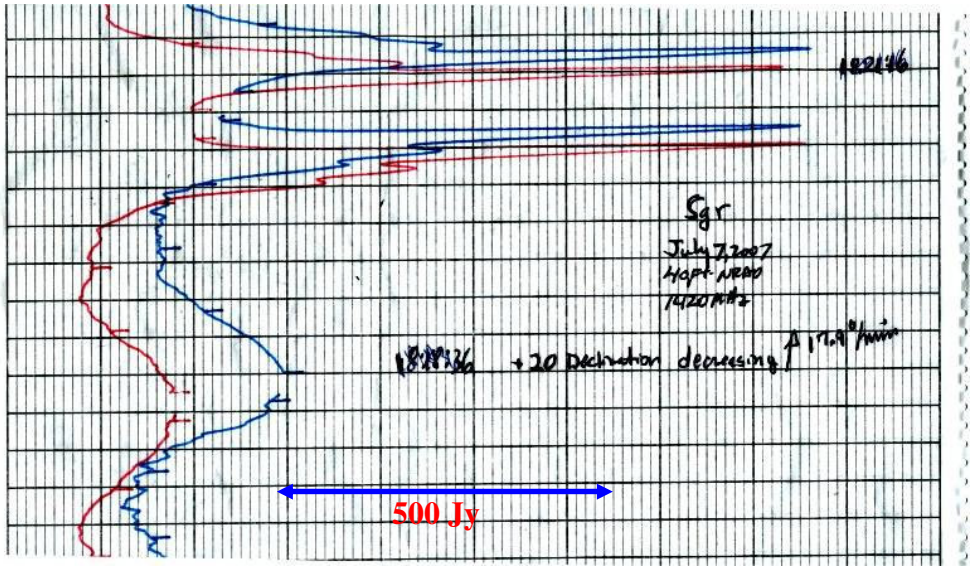


Figure 19: The central portion represents one of twenty scans of the Milky Way near the galactic center started around 18:18 LST (RA). This run ramped the declination motor from +20º to -20º at 17.9º per minute. Both channels are shown and the chart speed is 3 cm/min. The y-axis is graduated in 1-inch major divisions disclosing a 950-1000 Jy radio source (blue channel).

Declination Motor Analysis

The linearity of the motor is fairly good in a given direction, but varies slightly between increasing and decreasing traverses through the declinations. The following variations in the 80 data points are conservative since they incorporate procedural errors, such as reflex errors, parallax errors, etc. (the rate of change of declination, $d\alpha_t(t)/dt$, is discussed below):

Up	16.52 +/- 0.51 degrees/minute	standard relative error: 3.11%
Down	17.44 +/- 0.67 degrees/minute	standard relative error: 3.86%

Average difference between Up and Down: 5.38%
The antenna beam width (~1º) is greater than the variations.

Measurements on the Strip Chart Signals and Recording the Data

The tedious procedure for measuring and recording the RA, Dec, and Radio Flux (Φ) required coordination of two transparent rulers— one for each chart axis. Many hours were required to log the 300 data triplets. (Had the electronic data logging capability of the control room computer been operational, then more than 8 hours would have been saved. Tom Crowley is looking into restoring this valuable functionality.) In addition to the measurements of coordinates and radio flux in terms of chart parameters (cm), 4 calibrations with a 500-jansky source were performed— one at the beginning and end of the hour-long mapping and two in between. The reproducibility is very good with a 1.58% variation

$$60.32 \pm 0.95 \text{ Jy/cm}$$

For ease of measurements, all fluxes were measured relative to the chart zero, including baselines.

Data Entry in Excel

The voluminous set of data points (x,y,z) corresponding to (RA, Dec, Φ) were typed into the useful Microsoft Excel spreadsheet for subsequent analysis.

Data Reduction and Analysis

Times (read that as RAs) have been selected to represent the signal power profile faithfully. Therefore, the radio flux at 1420 MHz at some particular moment, $\Phi(t)$, is what determines which RA and Dec are important, together with adequate representation of the baseline levels. The measured flux (cm) is converted to appropriate units from the calibration noted above.

The right ascension at any instant, RA(t), is easily calculated. For the i^{th} scan (of 20)

$$RA^i(t) = RA^i{}_0 + x(t)/V_{chart}$$

Where x(t) is the chart position (cm) along the time axis measured with a ruler, V_{chart} (cm/min) is the chart speed and RA_0 is the starting local sidereal time for each run. Of course, the linearly increasing time is calculated in decimal fraction of minutes and converted such that the RA is expressed in hr:min:sec.

Similarly, the Declination, Dec(t), corresponding to the Right Ascension, RA(t), is calculated by assuming linear motor performance, at least throughout the nominal three-minute scan:

$$Dec^i(t) = Dec^i{}_0 \pm x(t)d\alpha_i(t)/dx$$

Where $\pm d\alpha_i(t)/dx$ is the average change in declination angle per cm of chart paper (deg/cm) throughout a particular i^{th} scan starting with $Dec^i{}_0$ (typically +/- 20º in this experiment). The sign is chosen for the direction of change (increasing/decreasing) of declination.

The time rate of change of the declination (summarized above in the declination motor analysis) is obtained using the chart speed,

$$d\alpha_i(t)/dt = V_{chart}\, d\alpha_i(t)/dx$$

Graphical Analysis

Unfortunately, Excel and many other plotting tools cannot be used to create a contour map unless RA and Dec appear as uniform intervals. Even if the applications allowed irregular intervals, special user-unfriendly data formatting would still be required: the RA must be entered as a column and the Dec as a row. The fluxes would then populate the matrix-like data format.

Currently, I am in the process of evaluating several software applications. Some are cheap, some, quite expensive. Perhaps the better ones have a discounted rate for educational use, such as for students and 501 (c)(3) organizations. I will report my findings in a future article. In the interim, I have produced a 3D-color chart using a demo of *Graphis*, version 2.9.09, [www.Kylebank.com]. This application easily handles irregular intervals (but seems to be less flexible with the contour plot). The 300-point 3D color contour plot is shown in Figure 20 and agrees well with various other representations of that part of the Milky Way (optical distribution in Starry Night, Kraus' radio contour plot, and Reber's seminal work shown in other figures in this article).

The radio target Cygnus A is a well-defined circular region whose width is about an hour of Right Ascension; however, it does spoke through the southern meridian in the early hours after 3 am, tough, but doable.

I want to encourage all of the SARA membership, whether you can attend the next conference or not, to acquiesce to the call of radio astronomy experimentation. Let us get involved in a group project/experiment. Many have accomplished meaningful experiments with very small telescopes (2 meter). This includes galactic rotation and I see mapping as a real possibility, despite the 6º beam width. Certainly, one can demonstrate that a source is extraterrestrial by comparing the total power drift scans on two consecutive nights. Perhaps a group "lab report" might make a nice entry into next year's post-conference journal issue. All of this can serve to motivate new members and encourage the "old timers." On that note, perhaps someone will "take the bull by the horns" (did I mention Taurus A?) and plan to video record the training session on the 40-ft. Some of our group experiments at NRAO could be included— radio astronomy being done *in situ*.

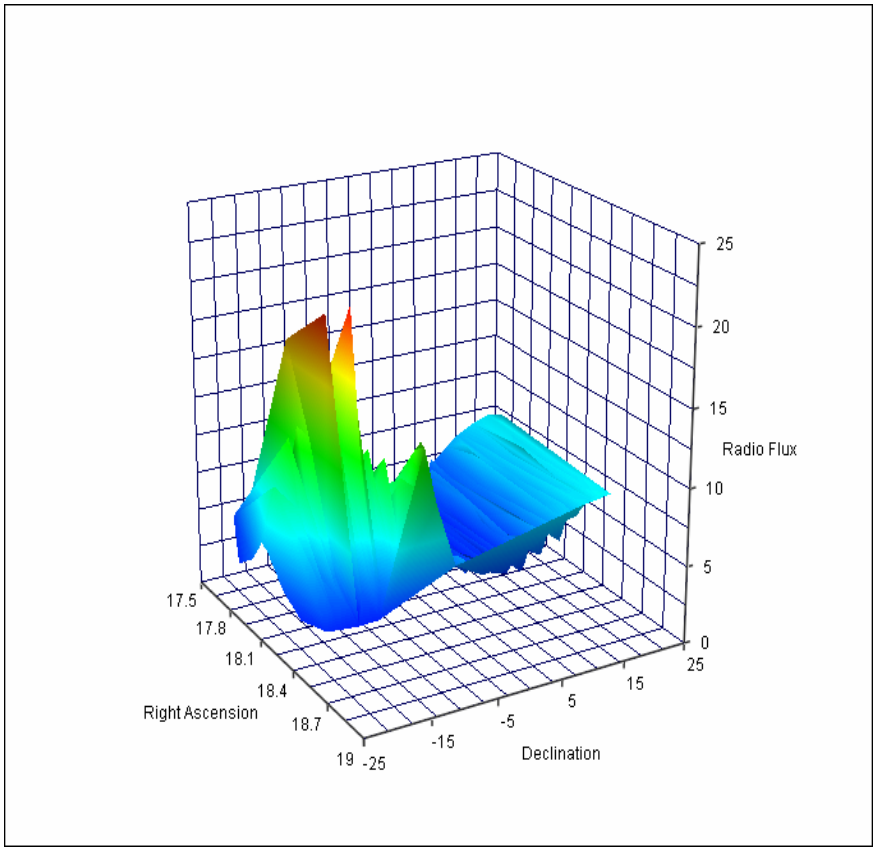


Figure 20: A 3D-color plot or mapping of a portion of Sagittarius. The data was acquired without the benefit of electronic data logging. Radio fluxes (shown in centimeters, 1 cm = 60 Jy) were read from strip charts and data reduced in Excel. The plot was generated using *Graphis* software.

~ Solar Radio Astronomy Miscellany~

Sun Drawings

An exhibit at Haystack Observatory near Boston, MA, connotes the power of the visual experience. The dynamical sun is captured in Jan Saad-Cook's innovative and unusual sculptures of special glass and metal. [http://www.haystack.mit.edu/hay/sun.html]



Figure 21: Sun Art by Jan Saad-Cook

A "Sun Drawing" is a changing image of light. To create one, the artist shapes and assembles reflective materials (mirrored metals and optically coated glass) and positions the reflective sculpture in the path of direct sunlight. As sunlight interacts with the sculpture, an image of light gradually appears on surrounding walls and ceiling. This image slowly and subtly changes as sunlight completes its passage across the sculpture.

The optical coatings on the glass are multi-layered interference coatings that break light into its pure colors. No pigments are used. The colors in a Sun Drawing are pure colors of sunlight. The artist determines the colors, shapes transitions and images by the way she forms the glass, the type of interference coating layered onto the glass and the way she combines the coated glass with mirrored metals.

Sunspots

The solar terrestrial activity report, [http://www.dxlc.com/solar/], and other comparative data, help us to follow solar activity. The telling sunspot number is more complex to determine than one might think, [http://spaceweather.com/glossary/sunspotnumber.html]. Even though we are at solar minimum, significant sunspot activity has occurred in the last couple of months. In fact, a rapidly growing sunspot has just appeared as I am writing this entry (July 28, 2007) [http://www.spaceweather.com/]. Look for solar flare radio emissions in 15-meter and 2-meter bands (as well as others). A comprehensive site for space weather is the Space Environment Center, [http://www.sec.noaa.gov/index.html]. I

might also add some interesting reading concerning solar activity, global warming, and related topics at [http://environment.newscientist.com/channel/earth/climate-change]. Finally, I will close with a light piece of poetry from my collection on *Sunscapes*:

Sunspots

Like twirling overcooked spaghetti
magnetic field lines twist and break
in hot swirling plasma. Giant hurricanes
anchor the broken strands,
for a while.
But the constant churning, year after year
incites the sun to riot. And the heat
of outrage breaks out every decade or so.
I suppose much like a labor union
with an agenda on a time clock.
Or perhaps, it's just an adolescent sun
that flares up when its face gets blemished
by all those spots.

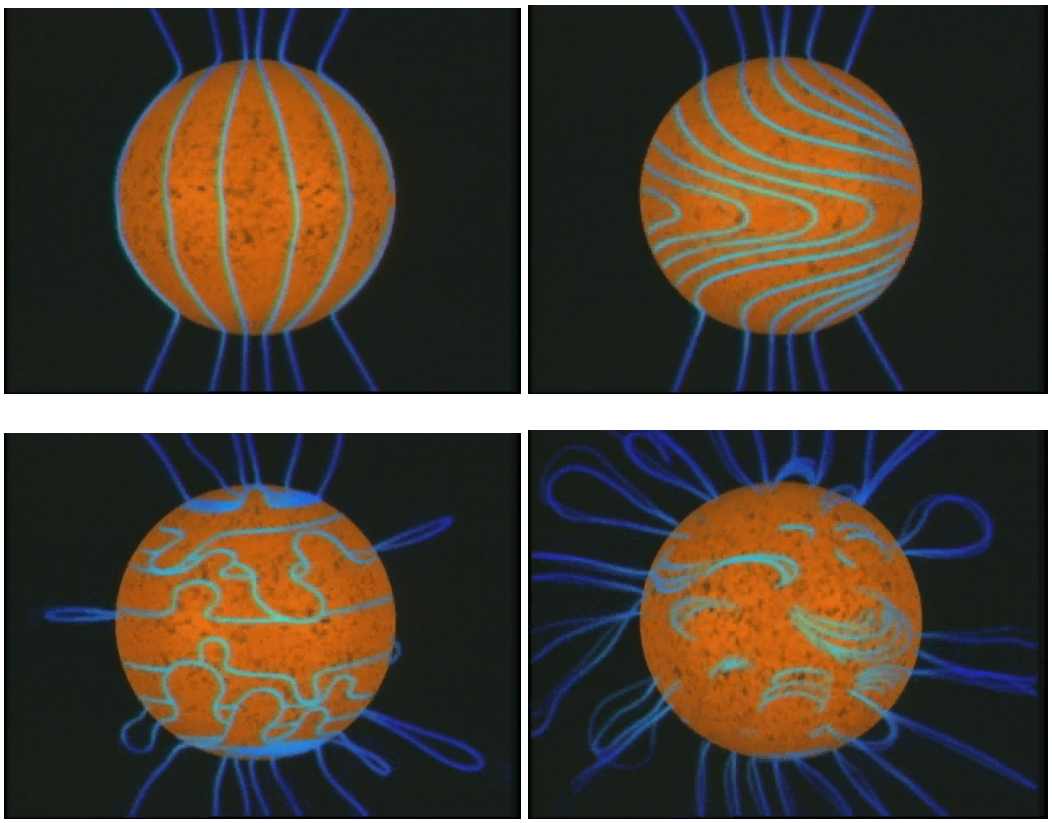


Figure 22: Sequence of stills from the NASA SOHO mission: *The Dynamic Sun*, version 5.0, is showing the twisting of magnetic field lines and sunspot formation due to differential rotation.

~ New Members ~

Please join me in welcoming our new members to SARA. (Contact the Treasurer for any corrections, missing information, etc. and copy the Editor. Thanks.)

Mike	Kirk	Mount Prospect	IL
Michael	Simpson	Ogden	UT
Edward	White	Bear	DE
Joan	Chamberlin	Parsonfield	ME
Vince	Adams	McHenry	IL
Lee	Kitchens	Gold Canyon	AZ
Mark	Gibson	Raleigh	NC
William L.	Marshall	Oak Ridge	TN
Allen	Skean	Arlington	VA
Paul	Berge	Lyons	CO
Henry	Catherino	Rochester Hills	MI
James	Vance	Toledo	OH
Alvin	Ureles	Rochester	NY
Jack	Carpenter	Alameda	CA
Kent	Gardner	?	?
John	DuBois	Boxborough	MA
Bruce	Bodner	Norfolk	VA
Shawn	Price	Socorro	NM
Skip	Hardy	?	?
Heather	Fries	Oak Ridge	TN
William	Jacobs	Independence	WV
William H.	Barfknecht	Lebanon	OR

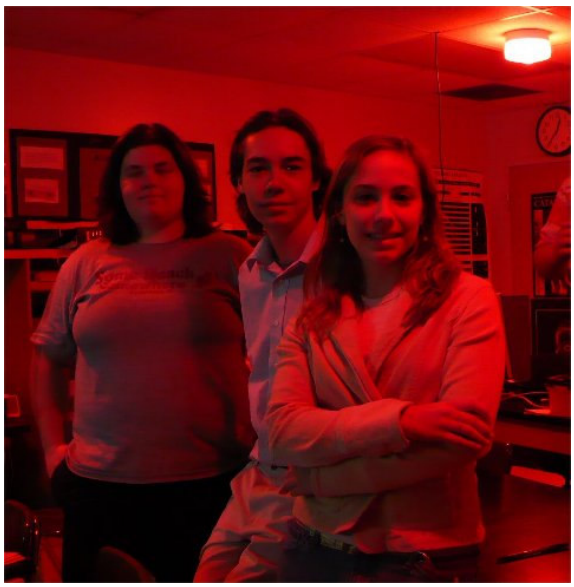


Figure 23: At a July 21 stargaze at Tamke-Allan Observatory: Heather Fries (left: new member and 2007 SARA conference presenter), Tyler Moore (center: 2006 and 2007 SARA conferences presenter), and Katie Sloop (right: Grand Prize Science Fair Winner for correlations of solar RF emissions with optical, satellite radio and X-ray observations). The red lighting helps preserve optical dark adaptation for this particularly pristine night. (*Photo credit*: David Fields).

~ Radio Astronomy Resources ~

SARA
http://radio-astronomy.org

Radio Astronomy Supplies
(Jeffrey M. Lichtman)
P.O. Box 450546
Sunrise, FL 33345-0546
(954) 965-4471 / jmlras@mindspring.com
http://www.radioastronomysupplies.com

Radio Sky Publishing
(Jim Sky)
PMB 242, Box 7063
Ocean View, HI 96737
(808) 328-1114
http://radiosky.com

NRAO
http://www.nrao.edu

Jamesburg Earth Station volunteer group
http://www.jamesburgdish.org
http://www.bambi.net/jamesburg.html

RF Associates
(Richard Flagg)
1721-I Young Street
Honolulu, HI 96826
(808) 947-2546

SETI League
http://www.setileague.org

European Radio Astronomy Club (ERAC)
http://www.eracnet.org/

Pisgah Astronomical Research Institute (PARI)
http://www.pari.edu

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