THE OBSERVER

NEWS FROM THE GREEN BANK OBSERVATORY
JANUARY 2018 - VOL II ISSUE 1

DIRECTOR'S NEWS

We have just finished our first full calendar year as the Green Bank Observatory. It has been an incredibly busy year filled with many accomplishments, including the first high frequency seasons of the MUSTANG-2 and Argus high frequency instruments, and the commissioning of FLAG (and its associated beam-former), the most sensitive phased array feed system in the world. Full commissioning of the VEGAS spectral line observing modes is complete and initial pulsar observing modes have been released. We have enjoyed an unprecedented level of visitors to and media interest in the Observatory and the work we do. This year we also celebrated the 60th anniversary of the dedication of the Observatory, with a party looking back on the many accomplishments the site's telescopes have had over the years.

In addition to all the activities described above, this past October we held a workshop which looked toward the future of the Observatory over the next 5, 10, and even 20 years. Workshop participants laid out a number of possible ideas for the site, and, as discussed in the "Preparations for the Decadal Survey" article in this newsletter, we are now asking members of the community to help us turn those ideas into a plan for the next decade or longer. We hope all of you with an interest in the long term future of the GBT and the Green Bank Observatory will help us shape the coming decades.

Dr. Karen O'Neil
Director, Green Bank Observatory

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NEWS

ASTRO2020 PREPARATIONS

We are preparing a long-term plan for the scientific program of the Green Bank Observatory and the GBT for the period 2020 - 2030. This review of current and future instruments will provide input to the 2020 Decadal survey. If you have an interest in science at the GBT or GBO please join us in this process. We envision that there will be a few small workshops at various locations during 2018 to develop the science cases and instrumental specifications. You can signal your interest by signing up on our web site.

[greenbankobservatory.org/astro2020]

TRANSFORMATIVE SCIENCE FOR THE NEXT DECADE WITH THE GREEN BANK OBSERVATORY – WORKSHOP RESULTS

From October 16 through 18, approximately 40 people gathered together to discuss possible scientific and instrumentation plans for the Green Bank Observatory in the 1-2 decades. The format of the meeting was designed to encourage significant discussion on topics ranging from star and galaxy formation and evolution through gravitational waves, pulsars, transients, astrochemistry, solar physics, the search for life, and solar system science. Each group of talks was followed by a discussion period on both the science and also how the Observatory can aid in accomplishing the science goals.

At the end of the workshop, we discussed the unique roles the Green Bank Observatory could have in accomplishing the varied science objectives, and laid out a number of possible paths for the future. Over the next year we plan to turn many of these ideas into grants, instrumentation plans, and one or more submissions into the upcoming Astro 2020 decadal survey.

The majority of the talks from the workshop, as well as the summary slides, are available online.

[greenbankobservatory.org/transformative-science-conf/scientific-program/]

Anyone who is interested in continuing to provide input or in working with us on our long term Observatory plans and Astro2020 submissions should go online and register your interest.

[greenbankobservatory.org/astro2020]

A NEW LOOK AT IC342

IC342 is a face-on weakly barred spiral galaxy with a young nuclear star cluster surrounded by several giant molecular clouds. However, the connection between the bright nuclear bar and low surface-brightness or extended emission has not been well explored in the past. Using 12CO lines to trace molecular gas at both low and high densities, a new map depicts a high signal-to-noise image of the inner part of IC342 that includes the first spiral arm. These fully-sampled images of the distribution of dense gas in star formation regions and their precursor flows will show whether the amount of dense gas is sufficient to fuel the star-forming process.

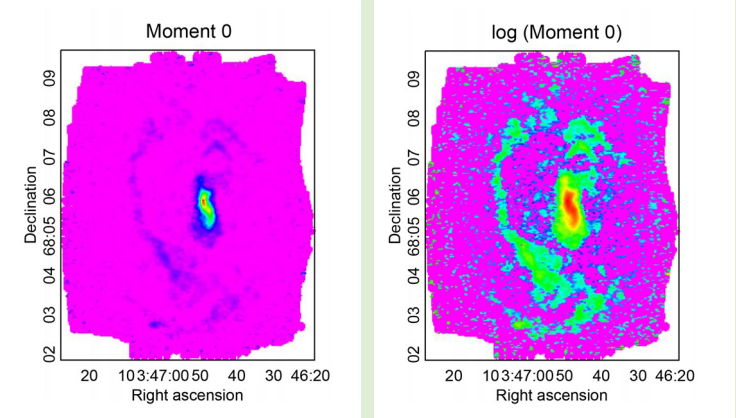

Figure 01: High-resolution images of the ground-state carbon monoxide spectral line at 115.27GHz. These panels show the overall distribution of CO as integrated intensity maps.

This new look at the galaxy was obtained with Argus, a 16-pixel focal plane array on the Green Bank Telescope. This millimeter-wave radio camera is able to make large-scale images of astronomical objects in a fraction of the time, and with higher image quality, that a conventional single-pixel reciever takes. Graduate student Jialu Li, in collaboration with the Argus instrument team and DEGAS project, made these images (the highest frequency spectral line

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observations the Green Bank Telescope has ever made) in only 10 hours on 2017 October 25 and 26. The combination of the GBT's 100-meter diameter and the short observing wavelength produces images with an unprecedented 4 arcsecond resolution for single-dish observations. This image, which is part of the DEGAS study of dense gas in nearby galaxies, shows the power of the GBT for observations of extended objects beyond our Galaxy.

The Argus millimeter-wave camera on the GBT produces data cubes of the emission from spectral lines with high spectral and spatial resolution. Data cubes have two spatial dimensions and a third dimension of spectral information, providing images of astronomical objects that show both the distribution and motions of gas. Figures 01 and 02 summarize the information from IC342's 12CO J = 1-0 spectral line data cube. Both IC342's nuclear bar as well as its inner spiral arms are clearly visible.

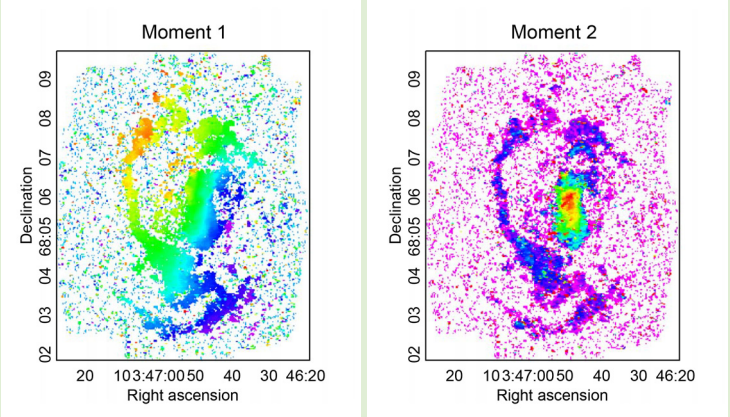

Figure 02: The "Moment 1" panel shows the change of velocity across the galaxy, indicating a smooth rotation, while "Moment 2" gives the spectral line's width, here showing a broad line toward the turbulent star-forming nuclear bar and more ordered motion in the arms themselves.

THE ARGUS+ PROJECT AT THE GBT

The GBT is now into its second winter season with Argus, the 16-pixel camera for spectroscopy in the molecule-rich 3mm atmospheric window between 74 - 116 GHz. Argus is the brainchild of Sarah Church of Stanford University and collaborators, who received an NSF ATI grant to design a modular receiver system for the GBT that could be replicated and expanded in a straightforward way. With the unique combination of angular resolution (6.5 - 9 arcseconds), sensitivity, and field of view of the GBT, Argus is being used for ground-breaking surveys of dense gas in galaxies and nearby star-forming regions. Some recent Argus results will be highlighted at the upcoming winter meeting of the American Astronomical Society in Washington D.C.

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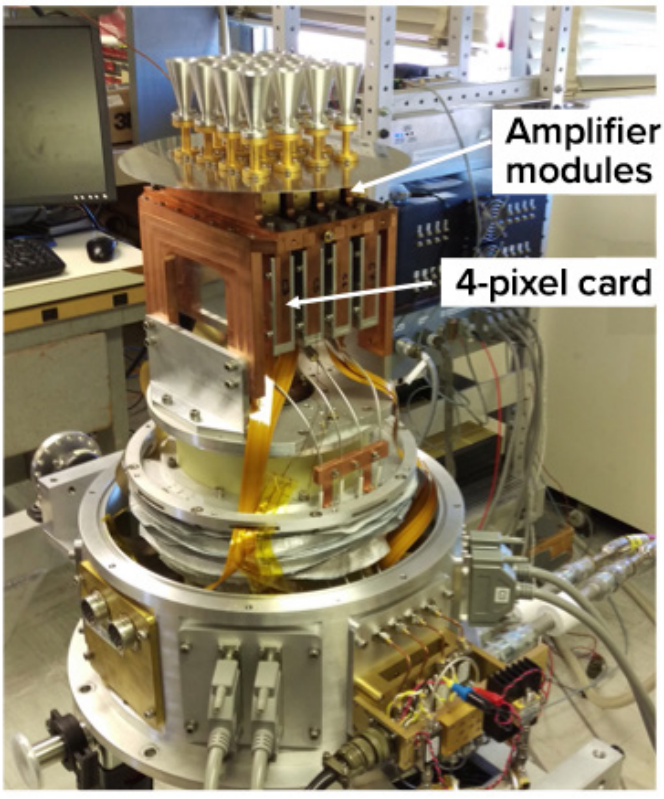

The Argus receiver highlighting the amplifier modules at top and the 4 x 4-pixel card array.

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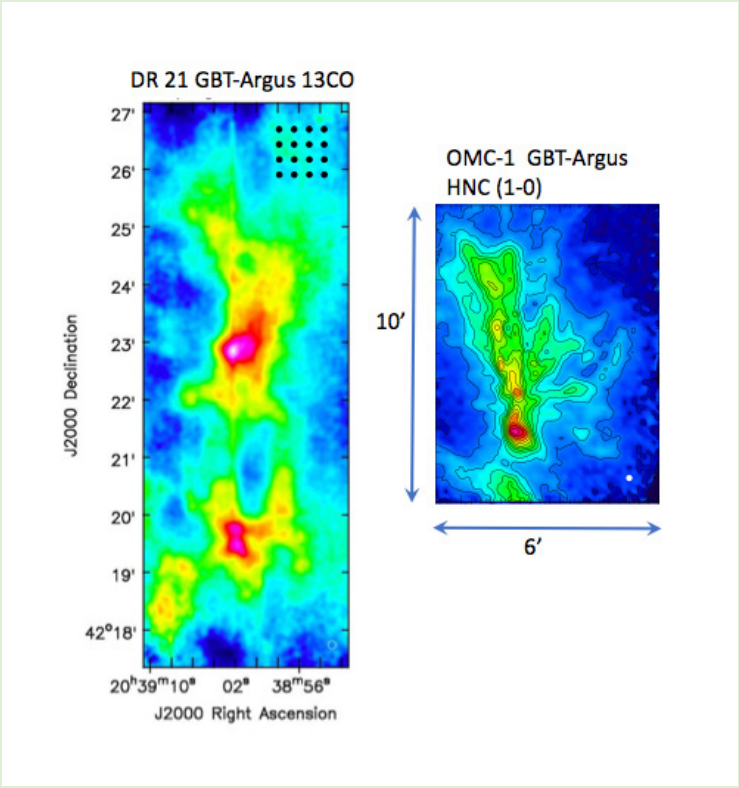

Left: Filament in DR21 mapped in 13CO. This map took 40 minutes in only moderate weather (τ=04). The footprint of the Argus array is shown upper right. Right: part of OMC-1 mapped by Argus in HNC(1-0). This map took 4.5 hours, including pointing, surface setting and calibration. The white circle shows the Argus beam (figure courtesy of Alvaro Hacar)

The Green Bank Observatory and the original Argus team are now collaborating on the Argus+ project, which would take advantage of the technical development afforded by Argus to produce a camera with ten times the mapping speed. Argus+ will also include a new spectrometer and improvements to the GBT metrology that would double the time available for 3mm spectroscopy each year. Argus+ will routinely produce spectral line maps of key species such as CO, HCN, and HCO+ with a spatial dynamic range (map area / pixel size) of 104 to 105.

As part of the Argus+ project the community will be invited to participate in legacy surveys with the new instrument. There will be a spectroscopic survey of the Gould Belt molecular clouds, and a survey of dense gas tracers in nearby star-forming galaxies. The legacy surveys will produce unique data of lasting value. Argus+ data will also be displayed in exhibits at the GBO Science Center, and will be incorporated into a range of programs in STEM education throughout the region.

The plan for Argus+ has been submitted to the National Science Foundation's call for pre-proposals to the Major Scientific Instrument Program (MSIP) with Felix J. Lockman (GBO) and Sarah Church (Stanford) as co-PIs. The project will leverage the NSF's investment in the prototype Argus to produce a uniquely powerful scientific instrument accessible to the U.S. scientific community.

Information on Argus+ is available on the ASTRO2020 web site.

[greenbankobservatory.org/astro2020]

2018A PROPOSAL CALL RESULTS

The 2018A call for proposals to use the GBT elicited requests for 4843 hours in 52 individual proposals. Twenty two proposals were approved for a total of 1748 hours.

The Time Allocation Committee Report for 18A can be found on the 2018A Proposal Call Results web page.

[greenbankobservatory.org/gbt-observers/proposals/past-proposal-calls/2018a-results/]

A listing of the accepted 18A proposals can be found on the 2018A Science Program web page.

[greenbankobservatory.org/gbt-observers/proposals/past-proposal-calls/2018a-science-program/]

SUMMER STUDENT PROGRAMS AND APPLICATIONS

The Green Bank Observatory summer student programs for undergraduate students runs from 10-12 weeks over the summer, from late May to mid-August. At the end of the summer, participants present their research results as a short talk and submit a written report. Financial support is available for students to present their summer research at a meeting of the American Astronomical Society, generally at the winter meeting following their appointment.

Besides their research, students take part in other activities, including a number of social events and excursions, as well as an extensive summer lecture series which covers aspects of radio astronomy and astronomical research. Students, may in their application materials, also indicate a willingness to participate in PING, an opportunity to mentor rising ninth grade students who will be onsite for 2 weeks.

The deadline for applications for 2018 is February 1, 2018. We will accept and review applications in conjunction with the NRAO summer student program again this year.

[https://science.nrao.edu/opportunities/student-programs/summerstudents]

GREEN BANK OBSERVATORY FEATURED IN RADIO ASTRONOMY COURSE

The Green Bank Observatory, and the GBT, feature prominently in a new course released by "The Teaching Company." The course, part of their "Great Courses" series is authored by GBO astronomer, Jay Lockman, and is called "Radio Astronomy: Observing the Invisible Universe". The "Great Courses" are not academic courses in the usual sense, but are intended to provide a college-level view of a subject for those outside the field, with no homework or tests. The company has over 200 courses on science and mathematics, and one of the newest is Jay's 24-lecture set on radio astronomy.

Dr. Felix (Jay) Lockman, author of the Great Course, "Radio Astronomy: Observing the Invisible Universe"

Besides providing a general overview of radio astronomy, the new course spends two "lectures" on an actual tour of the Green Bank Observatory. The first covers some of the historic telescopes like the Reber, Tatel, and 140 Foot. The second lecture is devoted entirely the GBT and includes a tour from the track to the top of the receiver room.

The course goes on sale every few months and is available online.

[https://www.thegreatcourses.com/courses/radio-astronomy-observing-the-invisible-universe.html]

RECENT GBT PUBLICATIONS

Sample publications based on GBT data that appeared within the last few months. A complete list for 2017 is available on our Web site. If your paper should be in that list but is not, please let us know.

Long-term Variability of H2CO Masers in Star-forming Regions, Andreev, N., et al. 2017, ApJS, 232, 29

The Breakthrough Listen Search for Intelligent Life: 1.1-1.9 GHz Observations of 692 Nearby Stars, Enriquez, J.E. et al. 2017, ApJ, 849, 104

The High-frequency Radio Emission of the Galactic Center Magnetar SGR J1745–29 during a Transitional Period, Gelfand, J.D. et al. 2017, ApJ, 850, 53

A Radio Counterpart to a Neutron Star Merger, Hallinan, G. et al. 2017, Science, 10.1126 aap9855

2MTF - VI. Measuring the velocity power spectrum, Howlett, C. et al. 2017, MNRAS, 471, 3135L

The Green Bank Ammonia Survey: Observations of Hierarchical Dense Gas Structures in Cepheus-L1251, Keown, ,J. et al. 2017, ApJ, 850, 3

Diffuse Ionized Gas in the Milky Way Disk, Luisi, M. et al. 2017, ApJ, 849, 117

Probing the Outflowing Multiphase Gas ~1 kpc below the Galactic Center, Savage, B.D. et al 2017, ApJS, 232, 25

Temperature structure and kinematics of the IRDC G035.39-00.33, Sokolov, V. et al. 2017, A&A, 606A, 133

The Green Bank Ammonia Survey: Unveiling the Dynamics of the Barnard 59 star-forming Clump, Redaelli, E. et al., 2017, ApJ, 850, 202

Deep K-band observations of TMC-1 with the Green Bank Telescope: Detection of HC7O, non-detection of HC11N, and a search for new organic molecules, Cordiner, M.A. et al., 2017, ApJ, 850, 187

HISTORY

SCHEDULING TELESCOPES: ASTRONOMERS AND THEIR SCIENCE

by Dr. David Hogg, printed with permission

It was my hope that by looking at how the NRAO developed its relationship with the users community I could better understand the way the Observatory evolved from its modest beginnings into the institution which has such a broad influence in global radio astronomy research. In the very beginning there was much controversy about the need for a national radio observatory and about how it should be operated. Eventually a process was developed under which a visiting scientist could submit a proposal to use one of the telescopes and obtain the data needed for his or her research. This process, developed in the early days at Green Bank, has endured throughout the history of the NRAO, albeit with modifications, some of them substantial.

The Principles of the Scheduling System

Once the 300-foot became available as a complement to the first 85-foot, the Tatel Telescope, it became necessary to formulate a policy which guided the selection and scheduling of observing proposals. A primitive first step had been taken in 1960 when the proposals were reviewed by Dave Heeschen, then the chair of the Astronomy Department. However, as the volume of proposals increased it became obvious that a more rigorous system was required.

Heeschen and AUI set out to develop a system which ensured that the proposals offering the best chance of producing important research would be awarded time on the NRAO telescopes. There was little guidance to be gained from the experience in optical astronomy, where the major instruments generally were managed

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by the sponsoring institutions, and the observing time was generally used by the staff of those institutions. AUI of course was managing the Brookhaven accelerators, and thus some of that experience informed the NRAO policy. In the end, the system was constructed on three principles:

- Acceptance of an observing proposal would not be based on institutional affiliation. This concept is often known as "open skies".
- All proposals, whether from visitors or staff, would be considered together, and would be peer reviewed.
- There would be no charge for telescope time.

Let me say a few words about each of these points.

The first principle, "open skies", was not without controversy. It was intended to bring the best ideas to the telescope, but there was criticism that the policy was not reciprocated by many foreign observatories, so that US observers felt that they were being treated unfairly. In addition, there were occasional inquiries from Washington about what fraction of time went to non-US observers. The principle has been reviewed several times over the years, and undoubtedly will continue to be so.

The election to use peer review was made both to ensure that the NRAO staff was not treated more favorably, and of course to try to maximize the use of the telescope time.

There continues to be no charge for basic science although more recently both the GBT and the VLBA do undertake some directed programs for which funding is received.

No scheduling system is perfect. The early days of molecular astronomy presented a special challenge, because it was pretty wild and woolly. A new detection often earned a paper in the ApJ Letters, providing motivation for keen competition.

Simply having access to the telescopes is necessary but is not sufficient. The instrumentation has to work, and the data have to be saved in a form suitable for the observer to work on and eventually publish. A structure was created in Green Bank to accomplish this. There would be an engineering division to design and supervise the construction of telescopes. There would be an electronics division to develop advanced instrumentation which exploited the most recent technologies. There would be telescope operations since the typical visiting scientist would be unfamiliar with these structures. Binding it all together was a support staff who understood that the success of the observatory is totally dependent on the success of the observer, and who therefore were dedicated to helping the observer achieve that success. I was reminded of this just a few days ago when Mike Balister recalled an especially challenging night during which he was called out to each of the three telescopes in turn. There are many familiar names from these times – Bill Horne and Sidney Smith, Hein Hvatum, Sandy Weinreb, and Art Shalloway, Fred Crews and Bob Vance – so many that I am not able to mention them all, but as a group they worked hard to keep the telescopes at the cutting edge. This institutional ethos, if I may call it that, has been at the core of the Observatory and I regard it as the reason for the success of the NRAO.

Dave Hogg has a long and varied history with NRAO and the Green Bank Observatory.He served as Assistant Director for Green Bank Operations from 1970-1974 and again from 1992-1993, as Assistant Director for Tucson Operations from 1985-1986,as Associate Director of NRAO from 1974-1979, and as Deputy Director from 2003-2004. He was involved in the development of the Green Bank Interferometer between 1962 and 1970, and was actively involved in the planning and development of the Green Bank Telescope. He became NRAO Scientist Emeritus upon retiring in 2005.

EVENTS

Deadline for GBT Proposals

February 1, 2018

Proposals for Proposal Call 2018b for GBT Observers are due Feburary 1, 2018.

[greenbankobservatory.org/for-observers/proposals/call-for-proposal-2018b]

Summer Student Applications

Deadline for Application, February 1, 2018

For undergraduate students.

[science.nrao.edu/opportunities/student-programs/summerstudents]

Remote Observer Training Workshops

January 15-16; May 24-25; September 17-18

Learn more.

[greenbankobservatory.org/gbt-observers/observer-training-workshops/]

Single Dish Training Workshop

Formerly Single Dish Summer School
May 19-23

For grad students, post-docs and experts in other fields of astronomy. Learn more.

[greenbankobservatory.org/gbt-observers/single-dish-training-workshop/]

Pulsar Search Collaboratory Online Workshop

February 1 - March 15, 2018

For high school teachers and high school students.

Learn more.

[pulsarsearchcollaboratory.org]

Pulsar Search Collaboratory, Summer Program 2017

CONTACTS

Green Bank Observatory
155 Observatory Rd
P.O. Box 2
Green Bank, WV 24944 (USA)
(304) 456-2011

GENERAL CONTACTS

Reservations, Field Trips, Tours, Events, and General Information Reception; (304) 456-2011;
reservations@gbobservatory.org

Newsletter Information, submissions:
pvosteen@nrao.edu

Public RFI Questions:
interference@nrao.edu

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