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Editor:
Earl W. Phillips, Jr.
7893 Thornfield Lane
Columbus, Ohio 43235
614-764-0476

NAAPO Coordinator:
Dr. Philip E. Barnhart
Dept. of Physics/Astronomy
Otterbein College
Westerville, Ohio 43081
614-898-1516

Current Hydrogen Cloud Observations

Russell K Childers, Assistant Chief Engineer, OSURO

Date: Mon, 26 Apr 1993

Over the past month, the Radio Observatory has been observing a hydrogen cloud which Tom Van Horne has long suggested we observe. Tom looked through old SETI records years ago and made the discovery of a narrowband celestial radio source, detected around 1980. It did not look like a point source, but was rather distributed. Its shape and frequency suggested a cloud composed mainly of hydrogen. Hydrogen clouds are common in and around our galaxy. Many surveys have been made of hydrogen cloud distributions and their velocities. It was hoped that a detailed narrowband survey of the area would reveal the extent and origin of the phenomenon. The receivers used during the survey where Tom Van Horne found the source were a bank of 50 10 kHz bandwidth receivers. The input to the receivers was the output from two Dicke-switched feed horns, in the same configuration the OSURO uses today. The outputs of the receivers went to a bank of 50 phase detectors, which determine whether there was more radio power in one feed horn as opposed to the other. The receivers were centered on the hydrogen emission frequency (around 1420 MHz), and the frequency was changed slightly to correct for the Earth's doppler shift relative to the center of the galaxy. Data was processed and printed out once every 10 seconds by an on-site IBM computer. Tom found the source in these printed records. The current receiver system consists of a bank of 50 100 kHz receivers and a bank of 12 10 kHz receivers. The centers of the two receiver banks coincide, so 10 kHz channels 1-6 fall in 100 kHz channel 25 and 10 kHz channels 7-12 fall in 100 kHz channel 26. Thus, any signal which falls within the range of the 12 10 kHz receivers will also be received in 100 kHz channels 25, 26, or both. The outputs of the receivers go to a bank of 62 phase detectors. Like the 1980 receiving method, the phase detectors determine whether more radio power is in front of one feed horn or the other. I received the coordinates and frequency of the object from Tom Van Horne, then Steve Brown and I moved the flat reflector to the proper declination. Steve Brown wrote a computer program on the PDP/11 at the Radio Observatory site to collect data from the receivers at the proper time and frequency. The first few times the source was observed, starting on March 27, 1993, it appeared in 100 kHz channel 35, a full 1 megahertz off of the frequency given by Tom Van Horne. The source did not appear in the 10 kHz channels at that frequency, so I shifted the center frequency of the receivers up by 1 megahertz. The next time the source was scanned, it showed up well in the 10 kHz

channels. It appeared to be about 20 kHz in bandwidth, and about 3 degrees in extent. Since the source is so broad, the beams from the two horns interfere with each other, giving a confusing picture of the source. I decided that one horn would be much better to observe the source. In order to use only one feed horn, it is necessary to switch between the horn and a "reference". This reference can be a constant temperature resistor or other noise source. At first I used a liquid nitrogen-cooled resistor as the reference. The resulting picture of the source was much more revealing. The source appeared to be two sources separated by about 10 minutes of right ascension, each about 5 minutes of right ascension across. There may in fact be many sources, each at a slightly different frequency and position. In order to determine the angular extent of the source in declination, it was necessary to move the declination of the telescope slowly away from the source. After observing the source for two weeks, I began moving the RO beams south by 10 arcminute intervals roughly every three days. I quickly ran out of liquid nitrogen to cool the reference resistor, so Steve Brown and I hooked up the skyhorn as the reference. The sky horn has a large beam — much larger than the beams formed by the parabola — which is constantly looking overhead. This setup provides an average of the sky noise as a reference, and is the reference method used during the Ohio Survey. The performance of the system with the sky horn reference is very close to the system performance using the cooled resistor. Currently, we are observing 40 arcminutes off of the original declination. The power of the source has dropped off by about 20 percent. After the power of the source has dropped considerably, the declination of the RO will be moved to the north, and successive scans will be made down through the part of the source not previously observed. There in fact may be another hydrogen-emitting source close to the source of interest which is traveling with a different velocity. In analysis of the 100 kHz channels, one can see that channel 30 consistently shows evidence of a weak, diffuse source about 12 minutes of right ascension from the strong source. I changed the center frequencies of the receivers for a couple of days to put the source in 100 kHz channel 30 in the range of the 10 kHz receivers. The source was quite difficult to detect and seemed rather uninteresting, so I switched the receivers back to the strong object. It has been suggested that the motion of this hydrogen cloud may be producing different doppler shifts in different parts of the cloud. Bob Dixon has suggested a torus of gas whirling edge-on from our perspective. This data is being collected in part to provide some independent study credit to an undergraduate Electrical Engineering student studying under Dr. Chuck Klein. After observations of this object conclude, we will observe Cass A, an extremely bright radio source, for calibration purposes.

Then we will begin a full sky survey for SETI and continuum sources.

Figures 1-3 These plots show data from April 18, 1993. The data was coilected for one hour, from 11:15 to 12:15 Local Mean Sidereal Time (LMST). A single feed horn (east) was used, switched against the sky horn reference. The data was filtered with a 1 minute time constant, because the half-power baamwidth at this declination, +61 degrees, is 1 minute. The source appears to be 20 kilohertz in bandwidth and 20 minutes of right ascension across.

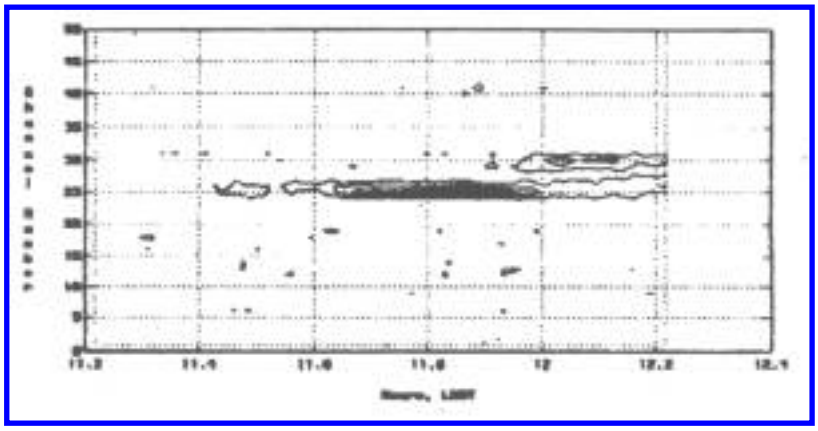

Figure 1 (at the right) is a contour of the frequency data from the 50 100 kHz receivers. The bottom of the figure is low frequency and the top is high frequency. The total bandwidth is 5 megahertz. The radio source under observation is located in channel 25. Note a fainter source in channel 30. The contours start 10 above the noise and are drawn at increments of 20. [Note. The horizontal axis is Local Mean Sidereal Time (LMST) in hours from 11.2 to 12.4 (left to right), and the vertical axis is Channel Number from 1 to 50 (bottom to top). Click this graph to see a larger image (although the readability remains poor due to a poor quality reproduction on the printed newsletter).]

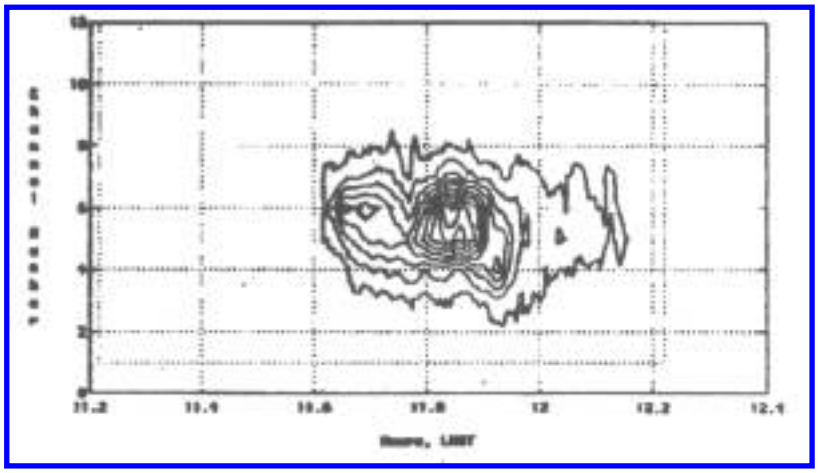

Figure 2 (at the right) is a contour of the frequency data from the 12 10 kHz receivers. The bottom of the figure is low frequency and the top is high frequency. The total bandwidth is 120 kilohertz. This bandwidth is 46 times narrower than the coverage in Figure 1. The contours start 60 above the noise and are drawn at increments of 60. [Note. The horizontal axis is Local Mean Sidereal Time (LMST) in hours from 11.2 to 12.4 (left to right), and the vertical axis is Channel Number from 1 to 12 (bottom to top). Click this graph to see a larger image (although the readability remains poor due to a poor quality

reproduction on the printed newsletter).]

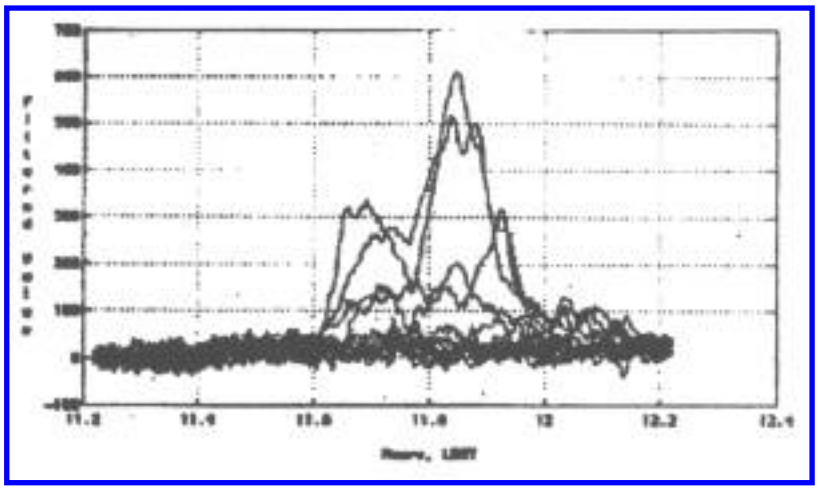

Figure 3 (at the right) is a line graph of the same data as shown in Figure 2. It is as though one were looking at Figure 2 on edge. Note the appearance of internal structure, both in frequency and in position. This structure is consistent over repeated observations. The amplitudes of the channels represent the inputs to the computer, where +2047 equals +5 volts, and -2048 equals -5 volts. Since the east horn was used, all voltages caused by radio objects should produce positive voltages when in the beam. [Note. The horizontal axis is Local Mean Sidereal Time (LMST) in hours from 11.2 to 12.4 (left to right), and the vertical axis is Filtered Value from -100 to 700 (bottom to top); the vertical value 700 corresponds to about 700 x (5 V/2047) = 1.71 V output from each analog-to-digital (A/D) converter. Click this graph to see a larger image (although the readability remains poor due to a poor quality reproduction on the printed newsletter).]

(ed. note). *The graphics for this article were supplied by Russ Childers. Scans were made of the graphs by John Ayotte for use in Signals.*

scr PROGRESS!
From: Angelo Campanella Date: Sun, 25 Apr 1993

SUCCESS! How sweet it is! The ancient IBM XT surrendered to our force and allowed that a strip-chart program could be purveyed through it! The final blow came via a DOS shareware program called 'infoplus' that allows one to read virtually every parmeter of any machine on which it is invoked. I therefore learned the proper HEX address for LPT2, and it was 'all downhill from there'. At the moment it is chugging away, imprinting a dot (period character) every 10 seconds at an analog location across the paper proportional to the continuum voltage (averaged over 10 seconds). The chart speed coresponding to 10 seconds per pop is 10 inches per hour (more or less). In addition, each hour on the hour, it imprints the time and date as an elemetary annotation. Not to be an exception, it has developed a "bug" in

this 'beta' version. After invoking one of the human interventions allowed, it then prints a crazy character on the low margin each minute. Why, I cannot say, but if you just stop it (<ctrl>-<Break>) and then restart it (F2), this glitch is avoided (until the next intervention). I'll look into that bug in the not-too-distant future. Some local instructions are there, printed on a piece of paper. This program is on the floppy disk in drive A:, and will auto-reboot if the power is interrupted. As Steve Brown has verified, this floppy is flaky. For the first hour yesterday, I did not think I would make it all work. I finally formatted a floppy disk in that very A: drive, then went to the newer PC to copy my files onto that formatted (with system) floppy, then hopped immediately back to the IBM XT (before it forgot itself) and copied from that floppy to drive C: the critical files. Then I used the floppy to edit the files, and so-far-so-good. I will evolve a "user's manual" over the next few weeks, and then post it here, in progressive (evolutionary) stages.....

5/1/93 MEETIING NOTES

The meeting began at roughly 10am. Those in attendance were Phillips, Dixon, Childers, Janis, Huck, Ayotte & son, Govrind Iyyuni, David Kopff [Kropff(?)], Bolinger, and Brown.

Dixon reports that he has received more info on the upcoming SETI conference in Santa Cruz.

Childers reports that he continues to receive data on the hydrogen cloud we are currently observing, and brings more graphs depicting same. He also reports that the cloud is drifting down in frequency, and Dr. Dixon gave a good explanation as to why this occurs.

Kropff [Kopff(?)] reports that he is creating a workstation program to visualize the continuum data.

Govind reports that he is helping Hanson on the card-to-tape project.

Phillips brings a book on the Dec-10 donated by Dr. Francis Graham from the U. of Pittsburgh, as well as a frequency allocation chart obtained at the recent Dayton Hamfest, for the focus room.

Janis has received a check for an overlay order from Poland, as well as inquiries

from several others for same.

Brown has been busy clearing trees that have fallen across the access road to the site, as well as backing up the Willard PC in preparation for that computer to take over the functions of the NCR-PC.

Ayotte has been scanning selected areas of the Ohio Survey into PC format, and will scan selected graphs from Childers' observations of the hydrogen cloud for Signals inclusion.

The meeting broke at roughly 10:45am, with most going off to their respective tasks.

Card Project - Hope Springs Eternal
From: Tom A Hanson Wed, 28 Apr 1993

Thanks to the interest shown by a new volunteer, **Govindarajan B. Iyyuni**, I have renewed hope that it will be possible to move forward with the card project. Govind is a PhD candidate in the Electrical Engineering department who already has a TSO account. We went through the procedure needed to obtain record counts of the boxes and trays read by Baker Systems staff, and Govind demonstrated understanding of the task and the ability to carry it out. After working with previously read boxes on TSO for a while, we entered the computer room and Govind demonstrated unusual patience and persistence in passing Box 268 through the maw of the card reader, overcoming numerous halts, but always following the proper procedure, so that a successful read will be assured. This box was one of those left unread by the previous crew. Govind has agreed to process the boxes, while I will perform the same action on the trays. Within a few days, we will be able to generate an index listing showing actual record counts. This information can then be applied to reading of those data sets which look promising onto mag tape, for transfer to the VAX for post read processing. This step will free up room at Baker Systems for the approximately 300 boxes remaining at Dreese Hall. It has been discovered that the asbestos removal at Dreese Hall, and the necessary relocation of materials previously stored in Dreese 817, have resulted in the apparent disappearance of great numbers of boxes. Steve Janis will investigate.

Assistant Chief Engineers Report
The OSU Radio Observatory

Today the flat reflector reached its north mechanical limit. Steve Brown and I stopped moving the reflector when we saw part of the ferris wheel on bay 9 (the easternmost) make contact with the "bath tub" underneath it. The surveying instrument used to measure the angle of the flat reflector (the theodolite) reads 63 degrees, 30 minutes. Because the feed horns are up off of the groundplane, the actual observed declination is one degree less, or 62 degrees, 30 minutes. This is the first time in YEARS that the flat reflector has been down this far. For the next month, I will continue to observe a hydrogen cloud close to the north galactic pole. I have recently scanned three degrees below the source, and now plan to finish the job. The data already collected is making some dramatic graphical images. I am creating "raster" images which will overlay each other, giving a false-color image of the spatial and frequency distribution of the cloud. The PC **Steve Willard** donated is working quite well as the brain of the **SETI** observing system, **LOBES**. Its graphics capability is far superior to the XT previously used.

5/15/93 MEETING MOTES

The meeting began at roughly 10.05am. Those in attendance were Barnhart, Dixon, Phillips, O'Connor, James, Brown, Childers, and Janis.

Barnhart reports that he will not be at the 6/5/93 meeting. He received a letter from **TRW** stating that the **Sun Workstations** are not available for donation. He has asked carpenter **Dick Smith** to take a look at the control hut for an estimate of repairs. The **NAAPO** account has roughly $6300.00.

Dixon reports that he has spoken with officials at **NASA** regarding our grant proposal. They say that it is approved, and we should begin seeing the funds around the first of July.

O'Connor has inspected the guy wires on the parabola, and feels that all external guys should be replaced. He gives ideas on who to hit for donation of materials, as well as several suggestions as to how to avoid future corrosion, as well as several improvements regarding the anchoring.

Childers brings more graphs from the hydrogen cloud observations. The scope is at

it's highest possible declination. He is going to try to produce a chart that includes the continuum data from the area as well.

Brown has increased the "swap-file" size on the 11/23, and is also working on the computers at Dreese in an attempt to get them running after the recent Asbestos removal project. All but the 11/750 is working fine. He and Russ will be working with **Jim Sheets** at **Perkins Observatory** to finish the security chain ordeal.

Janis has another order for the sky survey overlays, and has sold a spare VT-100 for $50.00.

Phillips brings another catalogue of electronic supplies, as well as a letter from the **Cincinnati Amateur Astronomy Group** requesting a speaker on radio astronomy; Barnhart may be able to comply. He has also volunteered to contact local companies regarding the possible donation of materials for the guy wire project.

James reports that he and Ang continue to work on the SCR project. He is going to replace the flaky floppy drive in the XT with one he is donating. A change in the programming will allow more frequent printing on the SCR project.

The meeting broke at roughly 11:15am, with most going off to their respective tasks.

COORDINATOR'S CORNER
KUDOS TO RUSS CHILDERS

The presence of hydrogen clouds — detectable by their 21-cm line emission — has been recognized for over 30 years. While there is much neutral hydrogen in the plane of the galaxy leading to attempts to map the spiral arms, Dutch observers in the early '60s found discrete clouds high above the galactic plane. Sorted out by their radial velocities into low, medium and high velocity clouds these large objects display a dynamic behavior tying them to the over-all structure of the Milky Way Galaxy. A few years back **Tom van Horne** found on the printed **SETI** records evidence of a broad, diffuse emitter of hydrogen not far from the northern declination limit of the 110-meter telescope here at

Delaware. He put in a request for further observation when we got back up to the northern sky. **Russ Childers** has made special effort to map this object in space and frequency. His preliminary report appears as feature article in this issue. This object appears on a survey of hydrogen clouds made in the early 70s by **Meng** and **Kraus**. It is one of the medium velocity clouds (about 42 km/sec toward us) and extends about 5 degrees across the sky. Russ is working on an algorithm to identify such clouds in the course of the **SETI** routine search because the pattern recognition algorithm and **LOBES** will both reject the data because of the large extent of the radiation across the sky. We owe a lot to Russ. He is bringing the instrument up to speed and all with a warm front end. ***Thanks, Russ!***

ed. note: *I am still on the look-out for a laser printer to produce* ***Signals*** *on. If you or your company happens to be upgrading, please let me know! The specifications are relatively easy: only needs to do 4 pages a month(!); parallel input, no fancy font cartridges. etc.*

[Back to List of Issues in Volume 9] | **[Back to List of Volumes]** | **[HOME]**

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