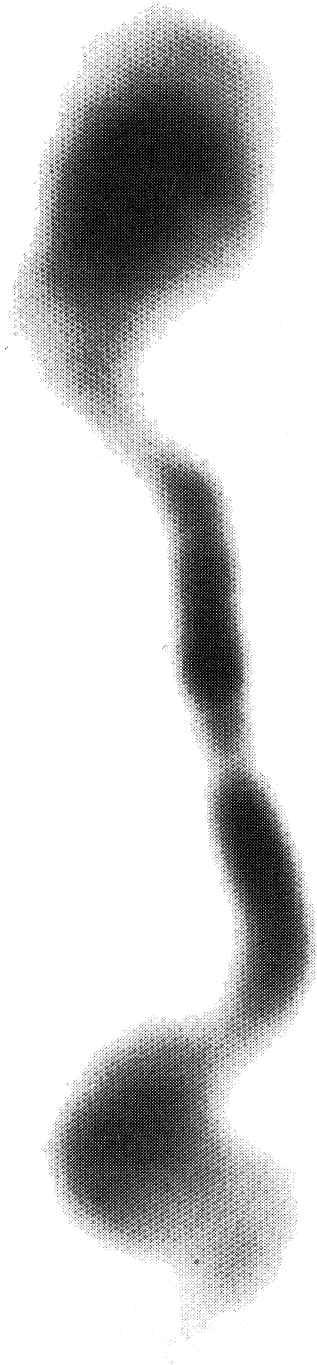


The **O B S E R V E R**

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Typist: - Victoria Taylor

Photography
and Printing: - Brown Cassell
Tony Miano
Ron Monk

Contributors
to this Issue: - Bill Brundage
Lois Chew
Ed Fomalont
Daryl Grant
Sarah Martin
R. K. Moore
Wally Oref
Lee J Rickard
May Rigby
Dave Shaffer
Jon Spargo

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P. O. Box 2, Green Bank, West Virginia 24944.

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tributed articles and who helped with the
assembly and distribution of the *OBSERVER*.

* * * * *

RADIO SOURCES WITH JETS

Ed Fomalont

The resolution, sensitivity and quality of the radio maps now being obtained by the VLA, exceed the capabilities of any other array in the world. Scientists from all over the country, Canada and Western Europe have travelled to the Plains of San Augustin to use the VLA. Radio waves from celestial objects as close as the sun and planets (even Earth-orbit satellites), and from quasars near the observable limits of the universe have all been observed by the VLA during its first real year of operation.

The VLA is now probing one of the most puzzling of astrophysical problems - the nature of the radio emission associated with distant galaxies. The energy output from these objects is so enormous that it equals the energy from one trillion suns. Just as remarkable, this enormous amount of energy is transported many millions of light years with great efficiency from its region of birth in the dense regions of a galaxy into the emptiness of space. From the detailed radio maps now being produced at the VLA we are able to probe into the heart of these sources.

To set the cosmic stage of these sources, let's start at a familiar level. On a clear night the sky is filled with myriads of stars, about 4000 are visible to the naked eye. Most of these stars are less than 1000 light years from us. On a moonless night a faint band of light, the Milky Way, can be seen. The band is caused by the combined glow of many faint stars and by luminous clouds of hot hydrogen gas. Also, dark regions composed of cold hydrogen and heavy molecular gas and dust particles obscure some of the Milky Way. This entire collection of material is called a galaxy. Our galaxy contains about a billion stars and is 40,000 light years across. Viewed from afar the form of our galaxy is that of a pancake.

A few of the "stars" in the night sky look fuzzy. Most of these are groups of nearby stars too faint and close together to be seen individually. In about 1920 one of these objects in the constellation of Andromeda was found to consist of billions

of stars and to be located well beyond the boundaries of our own galaxy. Andromeda is, in fact, another galaxy very similar to our own, about 1,500,000 light years away (1 light year = 6,000,000,000,000 miles). With very powerful optical telescopes you can see billions of galaxies, each containing billions of stars. They come in a variety of shapes; some are pancake-like and show spiral features, others are elliptical, and others are somewhat shapeless.

For reasons which are unknown to astronomers a violent explosion occurs in the middle, the nucleus, of the galaxy, in about 0.1% of the biggest elliptical galaxies. The source of energy may be a huge black hole, a large number of supernovae, or as yet unthought of process. Some of the light and most of the radio signals we receive from these galaxies are produced by electrons moving near the speed of light in a magnetic field created as a by-product of the violent explosion.

Often millions of light years away from the center of the galaxies, in the cold empty region of space beyond any of the stars, there are strong radio signals. The radio signals come from two regions on opposite sides of the galaxy called radio lobes. These lobes are undoubtedly caused by the explosion in the galactic nucleus. The big question is: how is all this energy transported so far and so efficiently?

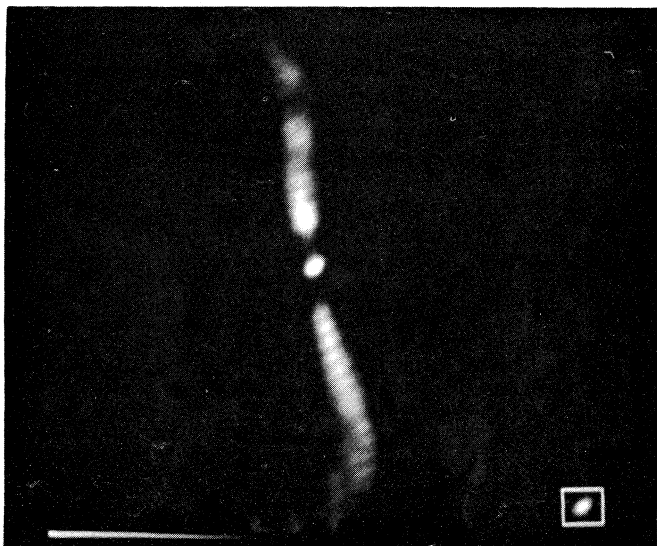
Until a few years ago astronomers thought that radio sources behaved like a bomb. After an atomic bomb explodes, the hot gases containing most of the explosion energy are buoyed up by the denser air and rise in a mushroom-shaped cloud. In the middle of a galaxy similar buoyant forces, caused by gravity and matter, would make the energy there expand into two clouds moving in opposite directions. The major problem with this model or explanation was that we could not explain how these radio clouds contained so much energy and yet were still so small after travelling millions of light years. After all, the mushroom-shaped cloud of an atomic explosion dissipates fairly quickly.

From recent observations at Westerbork in the Netherlands, Cambridge in England,

--continued, next page--

and the VLA we now believe that there is a connection or channel which ties the center of the galaxy to the radio lobes. This cosmic umbilical cord conducts a continuous supply of nourishment from its birth in the nucleus of the galaxy to regions many millions of light years away. This channel or jet can be seen in some radio sources such as 3C449.

One of the most useful methods of illustrating a radio source is by the use of a visual photograph. Suppose you could put on a special pair of glasses which allowed you to view the radio sky with your eyes. If you looked with these glasses just north of the constellation of Pegasus, now just visible in the West after sunset, you would see the radio image of 3C449 shown on the cover. Its total length is about 1/5 of the diameter of the moon. Perhaps most noticeable are the radio signals from a long tube or jet with a gap in the middle. The upper and lower extremes of the jet widen, become faint, turn towards the right and then open up into a puff-like radio lobe at each end.



A magnified picture of the jet is shown above. In the gap of the jet is an isolated region of radio emission, called a radio core. The ridges across the jet are not real but are produced in the process of making the picture and the thickness of the jet is probably much narrower in some places than the picture indicates.

To the naked eye there are no stars near the radio source. However, a photograph from a large telescope shows a distant, elliptical galaxy located precisely at the same position as the radio core. There is no doubt that this galaxy is the birthplace of the radio emission of 3C449.

Many radio sources are similar in appearance to 3C449 although variations occur. For the most powerful sources the radio jets between the radio lobes are not present. Since these objects were the first to be studied in detail, it is easy to see why the possibility of a direct connection between the nucleus and the radio lobes was only recently considered. It is generally believed that a flow of energy for these powerful sources does exist even if it is not visible. An analogy might be the shining of a flashlight in a dusty room. You can actually see the beam because the dust particles reflect some of the light. If there is no dust, the beam of light is invisible although light energy is still travelling along the beam. In a similar manner, if the particles in the jet move through a rarefied region with no magnetic field, they do not produce any radio signals. In 3C449 there may be enough material in the channel of the jet to produce radio signals.

There are other features associated with jets in radio sources. The jet is rarely connected to the radio core in the nucleus of the galaxy; it often begins about 10,000 light years away. Unlike a beam of light, the jets are not perfectly straight but have wiggles on them or a slight curvature. Sometimes a jet only appears on one side of the galaxy and other times only isolated segments of the jet produce radio signals. In one case, an optical counterpart of a radio jet has been found; hence the process which produces radio waves can also produce light.

These recent observations generally support one of the theories of radio sources, the so-called "relativistic beaming" model. In this model two nozzels (like the ones on a garden hose) are formed near the nucleus of a galaxy and the nozzels are then able to squirt two thin jets of high energy particles millions of light years

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before the streams are disrupted and expand into the radio lobes. Many astrophysicists at NRAO and elsewhere are trying to understand better the details of the theory by investigating the behavior of high energy particles in magnetic fields and in matter using large computers. Some of the major problems are: how are the nozzels formed, how do they propel the electrons, and how stable are they? what is the confining mechanism which keeps the jet narrow over vast distances? what is the process that disrupts the jet near the radio lobe?

Meanwhile, more detailed and higher quality maps of these radio sources will be made at the VLA in the next several years. These observations will complement the theoretical study in two ways. First, the best way to decide if a theory is correct is to make a prediction about some property of the radio source from the theoretical calculations and then try to substantiate that property with sufficiently accurate observations. The other way is to use existing maps of the radio sources to suggest the basic nature of the sources from which a theory can begin. For example, until the new maps were made most theories assumed that the radio jets were straight, like a beam from a flashlight. This is not the case, so that a theory must investigate processes in which the jets are able to bend and wiggle. This means that the jets must contain a "backbone" which can hold it together.

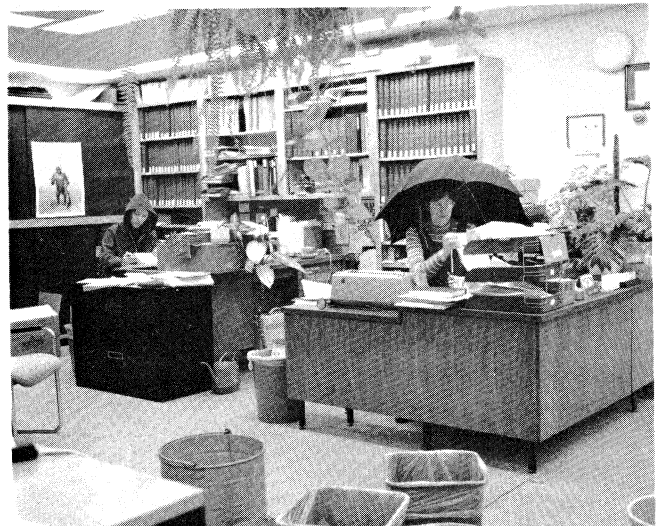
With hard work, luck, and insight perhaps the nature of the radio emission from distant galaxies will be better understood in the next ten years.



THE VERY LAST LEAKY ROOF ARTICLE



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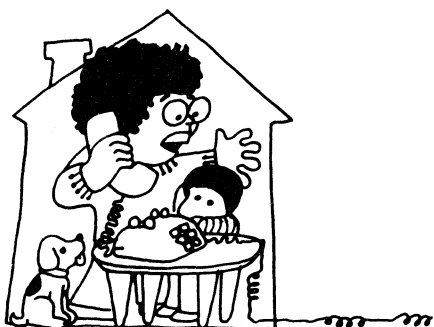
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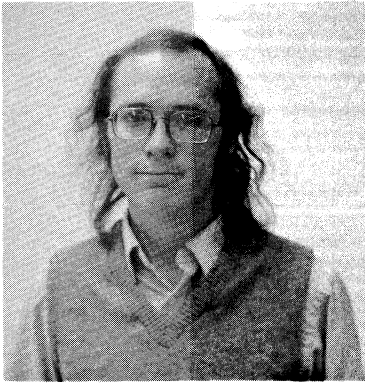
For Cancer Information Service toll-free number in your area, call toll-free directory assistance 800-555-1212 or call national office at 800-638-6694 (in Maryland call 800-492-6600)



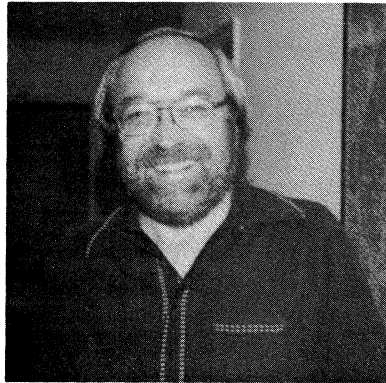
* From Ralph Nader's PUBLIC CITIZEN

PERSONNEL UPDATE

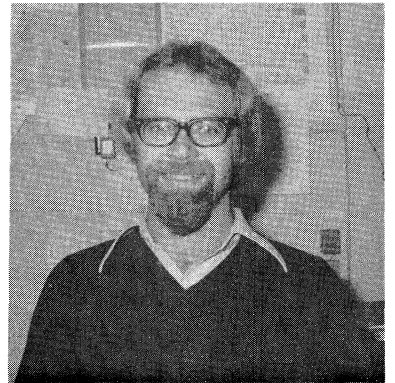
NEW EMPLOYEES



John M. Benson
Research Associate
Basic Research - CV



John W. Benson
Buyer
VLA - New Mexico



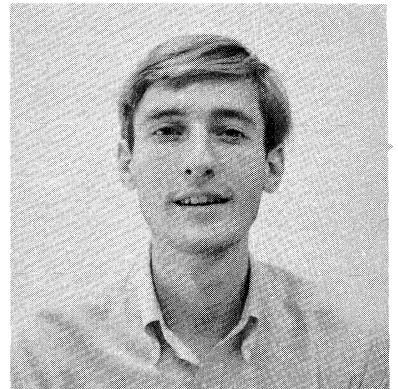
Larry L. Crouch
Technical Specialist
Telescope Operations - GB



Gary J. Garwood
Technical Specialist
VLA - New Mexico

PHOTO NOT
AVAILABLE

Charles E. Jarrett, Jr.
Technical Specialist
Telescope Operations - GB



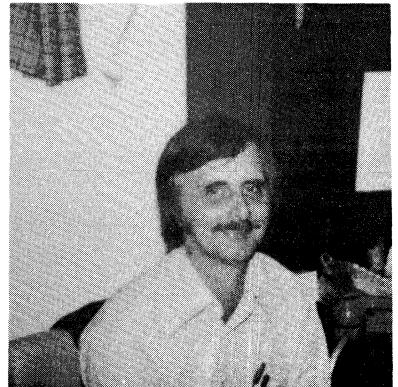
J. Christopher Placak
Computer Operator
Computer - CV



Marian W. Pospieszalski
Electronics Engineer
Electronics - CV



May Rigby
Personnel Assistant
Personnel - CV



Ronald H. Widener
Technician
VLA - New Mexico

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OTHER NEW EMPLOYEES - PHOTOS NOT AVAILABLE

Steven M. Aragon	Antenna Mechanic	VLA - New Mexico
Kevin P. Gallaher	Technician	VLA - New Mexico
Stanislaw Gorgolewski	Visiting Scientist	Basic Research - CV
Eric C. Nelson	Computing Aide Trainee	VLA - New Mexico
Jerrold E. Parmer	Technician	VLA - New Mexico
Simon D. M. White	Visiting Assistant Scientist	Basic Research - CV

REHIRES

Feliz M. Landavazo	Cook	VLA - New Mexico
F. Jay Lockman	Research Associate	Basic Research - CV

TRANSFERS

Jack O. Burns, Jr. to Basic Research - New Mexico
David L. VanHorn to VLA - New Mexico

LEAVE OF ABSENCE

J. Richard Fisher

TERMINATIONS

Darrell M. Burns	Edward E. Mullen, Jr.
D. Richard Decker	Hernan Quintana
Jan M. van der Hulst	Jean P. Ray
Faye M. Lewis	David M. Rosenbush



HAPPY NEW YEAR

THE 1978 JANSKY LECTURE

Lee J Rickard

Few scientists achieve celebrity. The exceptions attain their status more through popularization and politicization, than through the quality of their research. But the great exception among exceptions is Albert Einstein, who is regarded with equal awe by those who know his work as by those who do not. The centennial of his birth will be celebrated in March, 1979, and we may expect a resurgence of both popular and scholarly interest in his life and work. In anticipation of these ceremonies, it would be prudent to reflect on the precise circumstances of Einstein's fame. Such reflections were the substance of the thirteenth Karl G. Jansky Lecture, delivered by Professor Subrahmanyan Chandrasekhar. The following is a rough summary of his talk.

How can we account for Einstein's prominence? His professional reputation was established by a set of papers outlining the theories of special relativity, Brownian motion, and the nature of the photon. (They all appeared in 1905, which has come to be known as Einstein's annus mirabilis.) But in each, Einstein did not outstrip his contemporaries. Lorentz and Poincare were hot on the trail of special relativity; and it was Minkowski, not Einstein, who constructed its most general formulation. Smoluchowski discovered the explanation of Brownian motion independently, and unraveled it further. And Einstein's theory of the photon was but one of the steps to quantum mechanics, taken with Planck preceding and Bohr close behind.

Einstein's unique reputation is rooted in his creation of the General Theory of Relativity (GTR). The word creation is not used lightly here, for the field equations are not derived. Rather, they are approached, by arguments that depend largely on physical reasonableness, mathematical simplicity, and aesthetic sensibility. GTR is, as Hermann Weyl expressed, "one of the greatest examples of the power of speculative thought".

To appreciate this, it must be remembered that GTR was not developed to account for some basic conflict between observations and the Newtonian theory. Einstein's motivation was simply that the Newtonian theory of gravitation was inconsistent with special relativity, in that it assumed instantaneous responses to the gravitational field. In special relativity, responses must propagate no faster than the speed of light. This constraint can be incorporated into some physical theories - e.g., electromagnetism - by just adding retardation effects. But attempts to do that in Newtonian gravitation interfere with one of its most fundamental assumptions, the equality of the inertial and gravitational mass.

The concept of mass enters Newtonian theory in two ways. In Newton's Second Law of Motion, the force required to produce a certain amount of acceleration of an object is proportional to its inertial mass. In the Law of Universal Gravitation, the force felt by a body in a gravitational field is proportional to its gravitational mass. But we observe that bodies of different inertial and gravitational masses are equal. By recent experiments somewhat more subtle than Galileo's, this equality has been verified to one part in a trillion.

Thus Einstein's problem was to preserve this equality under the restrictions of special relativity. He was not immediately interested in practical questions. He had, after all, no reason to expect that a more accurate theory would predict anything other than small deviations from Newtonian behavior in common situations, where velocities are always much less than the speed of light. Indeed, he had no prior conception of what sorts of phenomena would be predicted at all. He was simply interested in achieving a harmonious resolution of special relativity and gravitation theory.

His solution was an elegant generalization of Newton's laws of motion, in which he incorporated the gravitational effects of matter into the actual structure of space-time. The beauty of this construction was immediately evident to the scientific community. But curiously, most physicists were more interested in admiring it than in ex-

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ploring its consequences. They tended to agree with Max Born, who said in 1955 (40 years after Einstein first presented the theory!): "The foundation of GTR was a great feat, but its connection with the world of experience is slender. Like a great work of art, it is to be enjoyed... from a distance."

A number of the major physicists chose to attack Einstein on the grounds of his ostensible abstruseness. Thus Whitehead, recalling J. J. Thompson's aphorism that the ultimate aim of science is to describe the sensible in terms of the sensible, remarked that Einstein's theory did not describe sensible things in a sensible way. E. A. Milne likened GTR to a garden where flowers and weeds both grew in profusion. "In our garden," he sniffed, "we grow only flowers."

Thus Einstein's fame did not flower first among physicists, who were content to treat GTR with a benign neglect. Rather, it originated with the public interest in one of the basic experimental tests of the theory. At the end of World War I, Sir Arthur Eddington led one of several British expeditions to observe a total eclipse of the sun. The basic purpose of the expedition was to test Einstein's prediction of the degree to which starlight would be deflected by its passage through the sun's gravitational field. Astronomy, always a subject of popular interest, was particularly appealing in those times as an endeavor transcending international strife. It was also exciting, because eclipse observations meant expeditions to remote parts of the globe. Thus Eddington's report of the success of the British expedition, given at the November 6, 1919, meeting of the Royal Society, was carried widely by British and American newspapers. Einstein was established as the savant of the age - the man who, if he had not actually shattered Newton's crystalline cosmos, at least had made it flex like rubber.

Eddington's role in the confirmation of GTR was actually a reluctant participation. He was eligible for the draft during the war, but intended to plead conscientious objection as a Quaker. However, in that case, it was likely that he would be expelled in

disgrace from Cambridge, and probably sent north to an internment camp. Attempts to get Eddington deferred as a distinguished scientist were thwarted when he appended a postscript to his deferment papers noting that he was a conscientious objector anyway. Finally, the Astronomer Royal, Dyson, got him deferred on the grounds that, should the war end in time, Eddington could best serve his country by leading the already planned eclipse expeditions.

Eddington was not particularly interested in going, because he was already fully convinced that GTR was correct. Indeed, the story is told that Eddington's compatriots were told to expect one of two results - a full deflection, in which case Einstein was right, or a half deflection, in which case Newton was still correct. And suppose the result were twice the expected deflection? Then, the answer was, Eddington will go mad and you shall have to come home alone.

Although rumors of the result had probably already reached him, Einstein first heard the news officially via a telegram from Lorentz. He responded with "heartfelt thanks". This is not to say that he was not confident of success. When later asked how he would have responded if the eclipse measurements had not confirmed GTR, he answered: "Then, I should have been sorry for the dear Lord - but the theory is correct!"

World War I contributed to the impact of Einstein's triumph in another way. Einstein originally calculated the deflection of light using the Newtonian theory, without including the GTR effects of the curvature of spacetime, getting half the true value. Findlay-Freundlich had intended to test the result in 1914 in Russia, but the war got in the way. Had the GTR value been derived after the observation, Einstein would have appeared just to be correcting his theory. It is doubtful that the newspapers would have been interested.

But while Einstein's popular fame may have been an accident of circumstance, his scientific stature is more securely based. As he himself said when presenting the theory in 1915, "Scarcely anyone who has understood this theory can escape its magic!"

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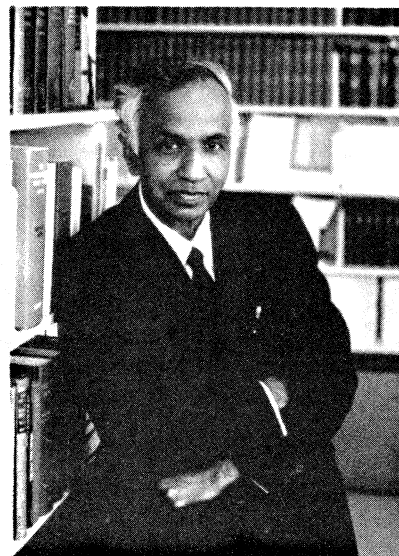
Physicists no longer admire GTR from afar. They recognize that it is rich in predictive content. And, contrary to popular impression, the conditions that GTR describes are not exotic. For example, the formation of a black hole occurs for stellar masses when they are compressed only to densities comparable to those of atomic nuclei. These conditions are not bizarre; the question is only whether they are frequent. Our present understanding of stellar evolution suggests that they are often inevitable.

The charm of GTR is both in its scope and in its precision. For example, one might expect that, if the only thing needed is a sufficiently strong gravitational field, there could exist black holes of any shape. But GTR predicts that the only black holes that exist are those conforming to the Kerr family of solutions of the field equations. In fact, one could sit at one's desk and write out a simple formula that describes every black hole in the universe.

If something should require some revision to Einstein's marvelous theory, then it would indeed be time to be sorry for the dear Lord.

Professor Chandrasekhar is the Morton D. Hull Distinguished Service Professor in the Departments of Astronomy and Astrophysics, Physics, the Enrico Fermi Institute, and the Committee on the Conceptual Foundations of Science at the University of Chicago. He is also a Fellow of the Royal Society, a member of the National Academy of Sciences, and served as managing editor of The Astrophysical Journal between 1952 and 1971. He has received the Bruce Medal of the Astronomical Society of the Pacific, the Gold Medal of the Royal Astronomical Society, the National Medal of Science, and the Henry Draper Medal of the National Academy of Sciences.

J. J. Thompson, eulogizing the great classical physicist Lord Rayleigh, suggested that there are two kinds of admirable scientists: those who have said the first word on a subject, introducing some new idea that has proved fruitful; and those who have said the last word on a subject, reducing it to logical consistency and clear-



Professor Subrahmanyan Chandrasekhar

ness. Professor Chandrasekhar's career disputes such a simple distinction, for he has influenced astrophysics in both ways. His first contribution, the proof that there exists a limit to the mass of stable white dwarfs, proved to be the first step toward the awesome realization of the inevitability of black holes. Quite recently, he has removed a great obstruction from the path toward the unification of quantum mechanics and general relativity by accomplishing the separation of the Dirac equation in the Kerr metric. In between, he has written fundamental texts on stellar structure and motions, radiative energy transport, magnetohydrodynamics, and mathematical physics.

And, according to a citation analysis performed by the Institute for Scientific Information, he is the most referenced author in the field of astrophysics.

CHAIN SAW ACCIDENT

Wally Oref

While using a chain saw on November 24, Carl Davis cut his left hand and nicked an artery. A week later I talked to Carl about
 --continued, next page--

the accident:

Carl, where were you cutting wood on the day of the accident?

On the upper side of the road going to Cass. On this side of the Tastee Freeze (Geno's).

What time did the accident happen?

It was about 9:00 a.m. I'd been there only five or ten minutes.

Exactly how did the accident happen?

As I mentioned earlier, I'd been in the woods only a very short time. I had cut down one small locust and then I cut a soft maple but instead of falling to the ground it hung up in a nearby tree. After I shut my chain saw off, I lifted the trunk out until it fell. Then I cut off the top end which left me with just the top to trim up. I wanted to trim up the last branch and cut it in two. Since my chain saw is one of those light ones, I reached down and picked up the branch and held it up with my left hand. As I turned the chain saw to cut this branch in two, the tip of the saw hit another branch, glanced off and hit me on the hand and across the wrist (the palm of my left hand was turned down). When I felt the sting I shut the chain saw off and set it on the ground. I looked at my left hand and blood was pumping up out of the wound.

Was the wound deep?

A very deep one. It went into the heel of my hand and far enough across my wrist to nick an artery. Right away I applied pressure and at about the same time I started walking very slowly out of the woods towards the road.

Did you feel any panic?

Not really, but I knew I was in trouble. I realized what I had done and I knew the possibilities of my not getting out of there, yet I was pretty calm although all kinds of thoughts went through my mind. The first thing I did was put pressure on the place where the blood was spurting out and to tell myself I had to stay calm and walk very

slowly so my heart wouldn't get revved up any more than it was.

How far were you from the road, and was it up or down hill?

I was probably about 150 feet from the road and it was steep and rocky down to the road so I had to pick my steps very carefully.

You were applying pressure on your wrist as you were going towards the road. Apparently it was still bleeding pretty good.

It was bleeding very good.

During the time you were walking towards the road did you feel light-headed or nauseated?

No, I never felt nauseated, dizzy, or even came close to blacking out.

So you made it down to the road okay?

I went to the middle of the road.

How long was it before someone came along?

It wasn't but a matter of a half-minute or so, I would say, until two vehicles came by. A truck load of hunters and a car from Cass.

And did both stop?

Yes; I flagged the truck down first. I took the pressure off my hand long enough to flag it down. The truck stopped and a bunch of hunters jumped out to help. The car from Cass stopped also and they asked what was wrong. I said I had a chain saw accident...could you get me to the doctor?, and they said they sure could. The hunters were the first ones to reach me and they are the ones who wrapped my hand up with a bandanna handkerchief and kept pressure on it and it was the guy from Cass who said "Come on, I'll take you in my car." One of the hunters got in with me and held pressure on my arm until we got to the Green Bank Clinic.

While Dr. Tanna was attending you, did he give you an assessment of the injury?

No. He wasn't there at the time.

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After the nurse put on a bandage, she applied pressure but the wound still bled very badlythere was a pool of blood on the floor and there was quite a bit of blood in the road after I had come down to the road. I lost a considerable amount of blood.

About how much time elapsed between the time of the accident and your treatment at the Green Bank Clinic?

About a half-hour. All this happened in about a half-hour.

I assume after they fixed you up at the clinic you went home?

No. They had to take the old bandage off and put a new one on. While this was being done the rescue squad from the Observatory came. One of them immediately applied pressure to the wound and kept holding pressure on my hand all the way to the hospital.

Which hospital did you go to?

Davis Memorial, and by the time we got there the bleeding had stopped. In fact, it hadn't bled very much from the time we left the clinic until we got to the hospital. They did a marvelous job.

What did they do to your hand at the hospital?

The first thing they did was take two X-rays, one with my hand lying flat, and the other with the hand on edge. Dr. Duckwall started surgery as soon as they cleaned up the wound. He tied up the nick in the artery, and sewed up the wound. It took eighteen stitches.

It's been one week since the accident. How does your hand feel now?

It feels like it is healing but it hasn't been looked at since I was at the hospital. I'm supposed to go back to the doctor in three days. My fingers move okay, but I'm concerned about a few nerves. They will probably take time to return to normal.

Do you feel, Carl, it could have been worse?

Do I?! I could have lost my life there mighty easy. If I had passed out

when I saw the blood, I'd have bled to death right there. There wouldn't have been anyone to find me before 12:00, when I was supposed to be back home for lunch.

What lessons have you learned from your experience?

I've learned two lessons: Never use a chain saw in the woods alone, and always keep two hands on the saw even if they say a light chain saw can be used with only one hand.

That's good advice for all of us who use chain saws. Incidentally, Carl, how long have you been using a chain saw?

For about twenty-one years. During all these years I've used a chain saw and never once nicked myself, but this time was a good one and....it could have been the last one. Even the most experienced chain saw user has to be very careful. You have to respect a saw all the time. I'll respect them from now on. I know they have the potential to cut off a hand, arm, or a leg. I've always tried to be careful, but sometimes you just can't be careful enough.



CREF UNIT VALUES - 1978

January	\$35.72
February	34.96
March	36.10
April	39.28
May	39.52
June	38.94
July	41.03
August	42.17
September	41.86
October	38.18
November	38.80

NEW CRYOGENICS AND FRONT END FACILITIES DEDICATED AT THE VLA

Jon Spargo

With little ceremony but lots of good cheer and plenty of rubbernecking, the newly completed VLA Cryogenics and Front End facilities were dedicated on Friday, November 17, 1978.

It was the culmination of six months planning and effort on the part of VLA management and staff to upgrade the work facilities for these two sections and thereby improve the reliability and performance of both cryogenics and front ends. The new shops, in addition to providing sorely needed workspace, also assure well-lighted, ventilated, and clean environments for the assembly, testing, and maintenance of cryogenics and front end systems.

Beginning earlier this year with antenna 13, the decision was made to equip all front ends with CTI cryogenics systems. Later, antennas 1 through 12 will be retrofitted with CTI cryogenics as additional spare sys-

tems are made available by the manufacturer.

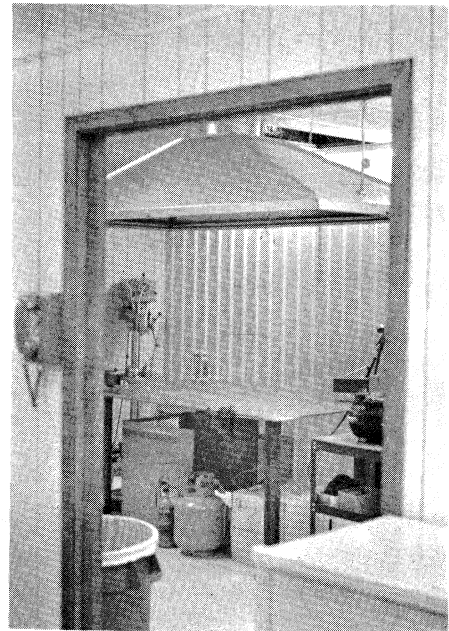
The VLA has already reaped huge benefits from this decision as the reliability of cryogenics systems has zoomed, and we expect it to be even better thanks to these two new facilities.

The planning for the new shops was headed by VLA Program Manager Jack Lancaster, Electronics Division Head Peter Napier, and Cryogenics Specialist Howard Brown on loan to us from Green Bank. Thanks to their efforts, planning and construction was completed in near record time and in fact the new shops were in partial use prior to their dedication.

As the accompanying photos by Daryl Grant show, the Cryogenics section under Rudy Latasa and the Front End section under Mal Sinclair can now enjoy the benefits of vastly improved facilities and indeed they are justifiably proud of their new homes.

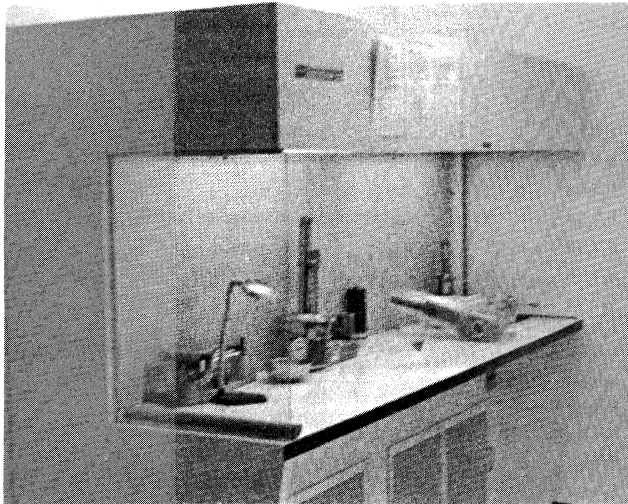


Main work area of Cryogenics lab.

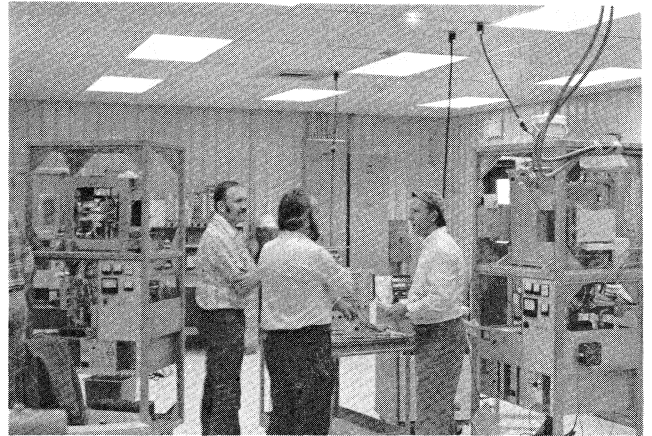


"Dirty" workroom showing exhaust hood over soldering and brazing area.

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New laminar flow workbench in "clean" room of Cryogenics lab.



View of new Front End lab complete with "celebrants" and two VLA front ends undergoing assembly and tests.

* * * * *

1979 NRAO HOLIDAY CALENDAR

Monday	01 January	New Year's Day
Monday	19 February	For Washington's Birthday
Friday	13 April	*Holiday
Monday	28 May	For Memorial Day
Wednesday	04 July	Independence Day
Monday	03 September	Labor Day
Monday	12 November	For Veteran's Day
Thursday	22 November	Thanksgiving Day
Friday	23 November	Holiday
Friday	21 December	½ Holiday
Monday	24 December	*Holiday
Tuesday	25 December	Christmas Day

* Additional Holiday

* * * * *

NRAO ROUNDUP

*Reprinted from the NRAO Quarterly Report
for July 1, 1978 - September 30, 1978*

ELECTRONICS DIVISION

Charlottesville

A week-long seminar was held to review the Model IV autocorrelator receiver for representatives from MIT and from institutions in Canada and Sweden which are copying the receiver.

Our first VLBI Mark III record terminal is currently being modified to provide full record capability and automatic control and monitor capability. The terminal will be ready for use at the 140-foot telescope in January 1979.

Work has begun on cryogenic GaAs FET amplifiers at 600 and 1400 MHz. Work is continuing on improving the performance of the 3-mm varactor down-converter. Development of Nb point-contact Josephson junctions is also continuing. The improved 1-mm subharmonically-pumped mixer has been tested and a second mixer of this configuration is being assembled. A liquid helium dewar is being adapted to permit cryogenic tests of the 1-mm mixer. A theory is being developed for comparison of fundamental and subharmonically pumped mixers at 1 mm. Specifications have been developed and a request for proposal is being prepared for a series of millimeter wavelength Carcinotrons to cover 3 to 0.75 mm range.

Green Bank

An improved 18-26 GHz maser has been installed on a 4 K refrigerator capable of cooling a 3-watt load, and is ready for the upconverters which will cover the 5-16 GHz frequency range. The 8.2-10.8 GHz upconverter has been fully tested at room temperature and cold tests are underway. AIL is having diode problems with the 12-16 GHz upconverter and delivery is very late. AIL has recently been awarded a further contract to develop an upconverter to cover 5-8 GHz.

The 300-1000 MHz receiver development is progressing. The dewar assembly has been started; an early prototype upconverter is

being tested. The material for the new travelling box track for this receiver has been ordered.

The digital standard receiver has been interfaced with the DDP 116 computer at the 300 foot and has been fully tested. This backend is available for observer use for continuum work at the 300-foot telescope.

Tucson

During this quarter the second 256-channel, 1 MHz per channel filter bank has been installed at the telescope. The new quasi-optical polarization splitter gives two good channels at the carbon monoxide frequencies, and the availability of a second 1 MHz filter bank gives a factor of two improvement in observing time to many observers.

In collaboration with B. L. Ulich, a new split disc has been developed that gives good standing-wave cancellation over a wide frequency range.

The diode contacting facility is now completed, and 23 are able to contact both 80-120 GHz and 33-50 GHz diodes here in Tucson.

A third compressor has been built, enabling us to keep the receivers cold in our laboratory on the mountain.

A fast mechanical switch has been developed that will permit more efficient observations with the 9-mm receiver.

ENGINEERING DIVISION

Preparations were completed for the measurement of 72 radii on the 140-foot telescope surface with the "stepping bar" surface measuring equipment. A conceptual design for a new drive system for the 36-foot telescope was started. Detailed design continued on the 300-foot traveling feed drive system and structure modifications. Refinements in the 25-meter telescope conceptual structure design along with other studies and research continued. A contract was awarded for the development of surface plates for the 25-meter telescope, using new materials and manufacturing techniques. Some engineering assistance was provided the VLA for inspection, operation, and maintenance. Routine

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engineering assistance was provided operations and maintenance in Charlottesville, Green Bank, and Tucson.

COMPUTER DIVISION

Map Processing Development

Work is continuing on the map/image processing system. Two 168 Mbyte discs purchased from Ampex have been delivered and are being installed. An array processor and a television-like display system have been ordered from Floating Point Systems, Inc., and Stanford Technology Corporation, respectively. Delivery of these items is expected near the end of the year.

IBM 360/65

The IBM 360/65 has been purchased. Extension of the lease through 1980, the minimum useful lifetime of this machine, would have cost more than the current purchase price.

140-Foot Telescope Manual

A manual describing the 140-foot control system has been written and is in print. Copies may be obtained from the Computer Division Secretary by requesting User's Manual Report Series #27, "Computer Assisted Observing: The 140-ft Manual".

IBM 360/VLA Data Reduction Programs

This program package is now being used routinely for both VLA and Green Bank interferometer data. Major developments are not planned, although experimental algorithms will be implemented from time to time. Recent additions include a flexible premapping convolution algorithm and some improved output map display routines.

VERY LARGE ARRAY PROGRAM

The array was scheduled for observations and tests 63% of the time during the third quarter of 1978. At the last of September, thirteen antennas were operational, with the longest baseline 11.5 km.

Design work on the new baseband IF system (Modules T3, T4, T5, T6) progressed during the quarter, as did testing of the prototype front end IF system (Modules F4,

F7, F8). The final design waveguide couplers have been installed in place of all the prototype couplers previously used on the East and West arms of the array. The coupler loss into the antenna waveguide has been reduced and the nitrogen leak rate on both the East and West arms has been reduced to less than the minimum detectable flow rate of 50 cubic feet per hour. Testing of the new correlator system was started and work progressed towards bringing it on line permanently. The first fringes were obtained with Antenna No. 15 on August 8, 1978.

VLA data can now be easily transferred to the PDP 11/70 computer, and map making software in that computer is being debugged. The new correlator system hardware was available for the first time for initial software tests in August.

The garage building was completed during the quarter and electrical wiring and air-conditioning work is in progress on the cryogenic lab extension. The Phase IV construction contract which was awarded to Pacific Railroad Constructors, Inc., has begun, with work well underway.

<p>THE BIG EAR: OR PIE (PIZZA) IN THE SKY BY AND BY</p>

Sarah Martin

Many NRAO employees outside of Charlottesville may have wondered why on occasion when they have called the library to seek some important chunk of information, they have been greeted with a laughing librarian at the other end of the telephone line. Since I'm sure this has elicited great concern on the part of the caller (Do they sit there reading joke books?" "Has she taken leave of her senses?" "Is my voice on the telephone that strange?"), I shall now attempt to set the record straight. We are not reading joke books. We are relatively sane. Your voice doesn't sound any more strange than usual. None of these possibilities is the real answer. No,

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the real answer is that we have just heard another weird remark from the reading room. You see, among the scientific staff, I am embarrassed to report, there are many candidates for the funny farm or at least for a brief sojourn at the Virginia Home for the Mentally Bewildered. Let's face it: the pressures of competition and continual assaults on a non-functioning computer have taken their toll. Previously fine minds have turned to mush and the library reading area is a haven for loonies of the first order.

To prove my point, I give you herewith quotes from recent conversations that have been overheard in the library. The parenthetical remarks following each quote are either my analysis of what they're trying to say or some other kind of explanation to make the quote clearer.

"Lukewarm pizza is still lukewarm pizza." (Let's go to lunch.)

"Justice will be done!!" (I'm gonna kill the guy who ripped off the current ApJ.)

"The one playing at the D. C. Playhouse is 'Teenie Buns'." (I told you there was more to life than astronomy.)

"A squirrel can deliver a whopping 22,000 pounds per square inch bite." (And if the current ApJ doesn't return, I'm gonna bring on the squirrels.)

"The latest thing in Sherwood Forest..." (The rest of the sentence was garbled, but one imagines that someone thinks he's discovered a galaxy full of radio-emitting trees.)

"What?! Do you want extra-greasy pizza?" (Please!! I'll eat anything if you'll just say we can go to lunch!)

"We want a multi-element pizza." (Someone is thinking of the VLA as a large pepperoni pie?)

"This struck me as statistically specious reasoning, so I have vowed never to support VLBI again." (A VLBIer had said the previous speaker shouldn't go to lunch at 9:30 a.m. because he'd just get hungry again sooner.)

"Fight VLB with a check-up and a check." (Anyone who doesn't want greasy pizza at 9:30 a.m. is sick.)

"Magnetohydrodynamics means never having to say you're sorry." (There's no

logical explanation for people who go around talking about magnetohydrodynamics and I shan't try to give one here.)

"The cats of Washington have a general density of 723 per acre." (You think it's crowded with three people in an office, huh?)

"Cats born under the sign of Cancer are much more likely to be show cats." (And astronomers living in Virginia are likely to be loony.)

"We theoreticians don't need data to mislead us; we're perfectly capable of doing that by ourselves." (The speaker got no arguments in response to that statement.)

A: "Do you have a merging galaxy to spare?"

B: (Silence)

A: "Well, I could have asked you for a quarter."

I rest my case.

<p>GERALD TAPE RECEIVES 'NUCLEAR STATESMAN' AWARD</p>

Gerald F. Tape, president of Associated Universities, Inc. and former U. S. ambassador to the International Atomic Energy Agency, tonight (November 15, 1978) was presented the Henry DeWolf Smyth Nuclear Statesman Award by two leading nuclear energy organizations, the Atomic Industrial Forum and American Nuclear Society. He accepted the award at a joint AIF-ANS banquet here (Washington, D. C.) during concurrent conferences of the two organizations.

Established in 1972 by the AIF and ANS, the award recognizes outstanding service in developing and guiding the uses of atomic energy in constructive channels. Dr. Tape was cited for "a reputation as a tireless worker for the policies and programs that would provide the benefits of atomic energy to all people of the world." The award was presented by William R. Kimel, dean of the College of Engineering, University of Missouri and president of the ANS.

Dr. Tape is the fourth person to receive the Nuclear Statesman Award, named

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after Dr. Smyth, a pioneer nuclear scientist, policymaker and diplomat. Dr. Tape received his Masters and Ph.D. in physics in 1936 and 1940, respectively, from the University of Michigan. In 1950, he became associated with Brookhaven National Laboratory, where he served as deputy director from 1951 to 1962. In 1962, he was named vice president, and later that year, president of Associated Universities, a group of Northeastern universities that operates Brookhaven National Laboratory for the U. S. government and the National Radio Astronomy Observatory for the National Science Foundation. In 1963, Dr. Tape was nominated by President Kennedy to fill an unexpired term as a member of the U. S. Atomic Energy Commission. He was reappointed in 1966 by President Johnson.

In 1969, Dr. Tape resigned from the AEC to return to the presidency of Associated Universities. Less than three years later, President Nixon appointed him as U. S. ambassador to the IAWA, a special agency of the United Nations headquartered in Vienna, Austria. He served in this post until 1977, while continuing as president of Associated Universities.

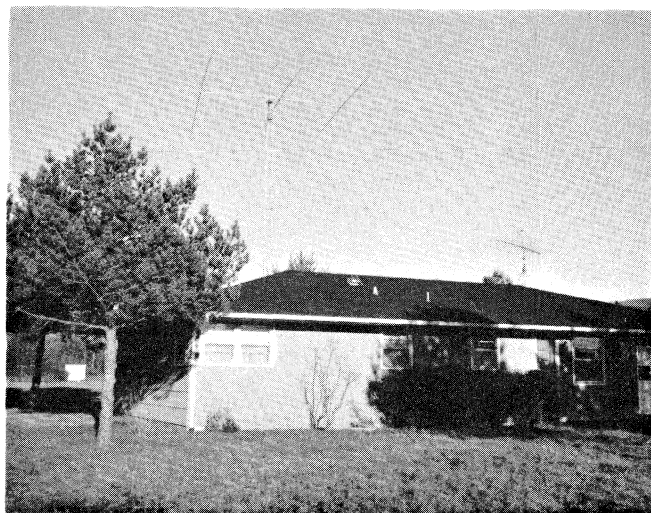
"HAMMING IT UP"
IN THE RABBIT PATCH

Dave Shaffer W8M1F

Those of you who have looked closely at NRAO house #5 in the so-called Rabbit Patch just north of Arbovale (perhaps some NRAO oldtimer would like to write a story about the origin of that term!) probably have noticed a rather imposing antenna tower. That is my ham radio tri-band Yagi antenna. The name Yagi refers to the original Japanese investigator of such antennas. Most TV antennas are relatives in the Yagi family.

The sizes of ham antennas and TV antennas are fundamentally determined by the frequency for which they are designed. The elements of the antenna are about one-half wavelength long. TV channels 2 through 13 have frequencies in the range about 60 to

300 MHz, or wavelengths of 5 meters to 1 meter. So, such antennas consist of pieces of tubing that are about $2\frac{1}{2}$ meters (8 or 9 feet) to $\frac{1}{2}$ meter (a little under 2 feet) long. The ham beam operates from 14 to 30 MHz (wavelengths of about 20 to 10 meters) and is correspondingly larger: 30-foot elements. A few ambitious (and rich!) hams have beams for frequencies as low as 4 MHz (75 meter wavelengths, or elements over 100 feet long!). The goal of the ham and TV antennas is the same: to send or receive signals from a certain direction with higher sensitivity (or gain) than possible from a simple all-directional antenna. Additionally, most antennas work better the higher they are in the air.



W8M1F Beam

My tower is about 40 feet high and required an afternoon of assistance from Mike Balister (WB4ZJO) and Al Wu (N8AK) to put up. (Beer is the ideal fuel for attracting and keeping such helpers.) Atop the tower is a heavy-duty rotator and the beam itself. The rotator and beam together weigh about 50-60 pounds. The whole affair is not especially cheap, but not too expensive either, about \$500 all told (plus beer).

What may not be apparent to the casual passerby is the collection of poles, wire, and cable that surround various other Rabbit

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Patch houses. This hotbed of hamming contains myself (W8MIF), Al Wu (N8AK), Mike Balister (WB4ZJO), Bill Brundage (K8HUH), and Marc Damashek (WAIUAB). The other NRAO Green Bank ham is Reg Atkins (W8LYW). Our call letters are issued by the FCC after we take a test on basic radio electronics, FCC rules, and show we can copy Morse Code. Various classes of license convey certain privileges of allowed frequencies and power levels. In general, the most popular bands are at 4, 7, 14, 21, and 28 MHz and power levels up to one kilowatt are legal (that's 200 times the strength of a CB rig). Most of us have transceivers (receiver and transmitter in a single package, like a CB rig) that operate at power levels of 100-200 watts.

What do we do with all this equipment, besides mess up your TV set and Hi-fi!? Actually, no ham deliberately tries to interfere with his neighbors. In this low-signal area, the booster amplifiers that everybody has for their TVs are very susceptible to overload from a strong ham signal. This fault, though, is really a design fault of the amplifier, as is much interference to other entertainment electronics. I can demonstrate almost interference-free operation of my TV, FM radio, and stereo while my ham rig is in operation only twenty feet away. Most of our local operation is at frequencies which do not bother the NRAO telescopes in any way.

Basically, hamming is a fun hobby. It gives you a chance to talk to people all over the world. I can talk on a daily basis with all of Europe and South America, and with just a little luck with Asia, Africa, and Australia. I have talked to 40 or 50 different countries. Some hams have "worked" 350 or more countries. (Many small islands count as "countries" for such purposes.) Some operators like to collect certificates that show their operating prowess. County-hunting is a favorite sport and makes Pocahontas County a sought-after contact. Much of hamming is just "rag chewing", getting on the air and talking to whomever wants to yak back at you. This popular past-time is, strictly-speaking, illegal on CB, as is CB DX (long distance contacts), and is the incentive for many CB'ers to get their ham license so they can

get away from the congestion on the CB channels.

Hamming is also useful. Many hams have equipment in their cars and can provide communications in emergencies, especially when power and phone lines may be knocked down. The long-distance nature of ham communications also provides links between remote outposts (ships at sea, Antarctica, Central and South American jungle missionary colonies, etc.) and the rest of civilization. I have had a fair success getting "phone-patches" to my friends in Boulder, Colorado and Tucson, Arizona. This technique allows hams on that end to connect their rigs to the telephone system and dial up my friends. I have had many conversations with Ken Kellermann (K2AOE/DJØRJ) in Germany and Mike Davis (KP4EPN) in Puerto Rico.

Anybody who is interested in becoming a ham should get in touch with one of us (I know there are NRAO hams in Charlottesville and Socorro, too) and we'd be glad to help you get a license. If there was enough interest, we could even start a class. Anybody can talk over the air, as long as a licensed operator is at the controls, so if you've just got an urge to talk to somewhere far away, let me know and we'll put you at the mike!

WHITEFLY

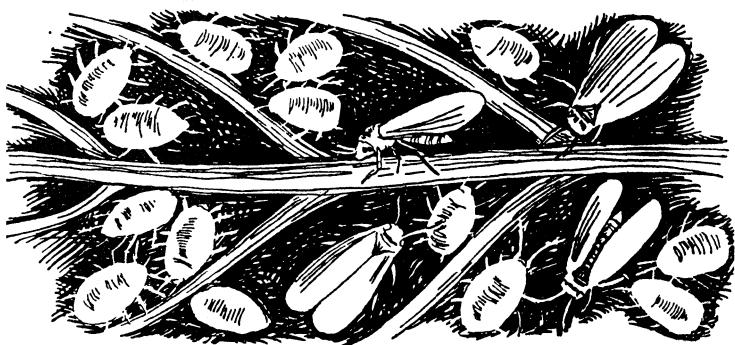
Wally Oref

Have you, after bumping one of your house plants, seen a bunch of white fluffs rise from the plant? If you have, what you saw take to the air was a house plant pest called the whitefly. It requires a good hand lens to examine an adult whitefly because they are so small. The adult whitefly starts life as an oval egg 1/100 inch long, hatches into a larva that goes through two molts and emerges as an adult after the second molt. Both the male and female adults and larvae suck sap from the underside of leaves.

The presence of adult whiteflies almost

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surely means there will be larvae on the underside of some or all the leaves. With difficulty you can see the larvae with the eye but a close examination requires at least a 10x hand lens. The average whitefly larva is not quite a millimeter long and $\frac{1}{2}$ millimeter wide. The dot inside this parenthesis (.) is about $\frac{1}{2}$ millimeter. They are oval, thin, flat, pale green, semi-transparent with white waxy threads radiating from their bodies. Their eyes appear elongated. Under a magnifying lens one can see a short snout protruding from between the larva's eyes. Thin and curved,



Larvae and adults of whitefly, much enlarged, on underside of leaf.

this snout is used like a hypodermic needle to extract plant juices from the leaves. Once the larva injects its snout, it sucks juice continuously until it passes into the pupa stage.

A few whiteflies and their larvae would not damage a mature plant. Unfortunately, whiteflies and their larvae don't come a few at a time. Once the adults gear up for egg production, larvae appear by the hundreds followed shortly thereafter by whiteflies by the hundreds. When large numbers of whiteflies and larvae are actively tapping the plant's sap, symptoms soon become apparent: infected plants lack vigor, turn yellow, sometimes wilt and die.

Unfortunately, both the adults and larvae are tough to kill and there are only

a few insecticides readily available to the homeowner. Aerosol sprays containing pyrethrins and rotenone are recommended to use against adults. However, they aren't very effective against larvae. Malathion does a good job killing both but has a disagreeable odor and should be used outdoors. Pyrethrins aerosols and malathion are about the only effective insecticides recommended in garden books.

In retrospect, practice of preventing whiteflies makes more sense. If you buy plants from a greenhouse, inspect them right there for whitefly. Plants received as gifts should be inspected as soon as discretion permits. Until inspection is possible, isolate your gift plant from the rest of your house plants. Inspect all house plants at regular intervals.

DIGITAL TELEPHONE SYSTEM D-1201

R. K. Moore

On December 6, 1978, NRAO-Green Bank switched over to a new digital telephone system which replaces the old system used since the NRAO was founded twenty years ago. The new D-1201 telephone system provides a broad range of features, yet requires a minimum of attendant involvement. Basically, the attendant's duties are limited to answering and extending incoming calls to the main NRAO number and giving general assistance to extension users. All features utilized after a call has been established are capable of being controlled at the extension.

A wide variety of the most modern communication features are inherent with the "digital" operation. Most of these features can be provided on a standard single-line telephone, eliminating the need for key telephone equipment at many locations.

The D-1201 provides direct inward dialing, automatic outward dialing, and many features such as CAMP-ON, AUTOMATIC CALL BACK, CALL FORWARD, CALL PICK-UP, CONSULTATION, CALL TRANSFER, and CONFERENCE. If, for

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example, you choose to use the automatic call-back feature, it will call you back when a busy extension you tried to reach is free. When the busy extension is free your phone rings. When you answer, the previously busy extension rings. You can still use your phone to make other calls because the call-back will take place only when both extensions are free.

The D-1201 system's solid state circuitry and advanced LSI (Large Scale Integrated) technology provides for up to 140 simultaneous conversations.

The NRAO installation includes a back-up (battery) power system insuring that telephone service will continue, uninterrupted, in the event of a commercial power failure. Only about nine square feet of floor space are required for the new equipment cabinet as compared to almost 275 square feet used to house the old equipment. The attendant console is approximately the size of two ordinary telephones and fits easily on an ordinary office desk. In fact, the new console and Janet Warner, the principal PBX attendant, who used to be in the first floor lobby-reception area are both located at the desk formerly occupied by Sis Michael in Purchasing/Property.

We are confident the new telephone system, with its many additional features, will benefit NRAO operations. Please check numbers in the newly issued telephone book before calling us. The new telephone system has required changing many extension numbers.

RABBITS, GROUNDHOGS, AND DEER - BEWARE

Last winter voles (repeat voles), mice, rabbits and deer did a lot of damage to trees and shrubs by girdling trunks and roots. When snow is high, damage is worse because of the cover. There is something you can do now to protect your plants; use tabasco sauce as an animal repellent. Mice, rabbits and deer do not like the hot spicy taste of tabasco pepper and one nibble seems to teach them a lesson they don't forget quickly.

Dr. Francis Gouin of the Department of Horticulture, University of Maryland recommends you try this repellent: Mix 1 tablespoon of either tabasco sauce or Louisiana hot sauce with 1 gallon of water. To make the sauce stick to the bark all winter use an anti-desiccant such as 2 tablespoons of Vapor-Gard or 4 tablespoons of Wilt Pruf (found in all garden stores) to each gallon of water. When temperatures are above 40 degrees F spray the susceptible parts of the plant thoroughly. Several Christmas tree growers will be spraying young firs (*Abies*) this fall to prevent winter browsing by deer.

The hot sauce can also be used to control summer browsing on nursery stock, using the same amount of hot sauce, but half the amount of anti-desiccant. Fast growing plants must be sprayed every 10 to 14 days to protect new growth. Deer check plants frequently to see if new growth is free of the hot stuff.

Dr. Gouin is testing a new hot sauce extract 25 times hotter than either tabasco or Louisiana hot sauce. If you use the hot sauce treatment tell us because we are working along with Dr. Gouin and want to gather as much data as possible on its use and effectiveness.

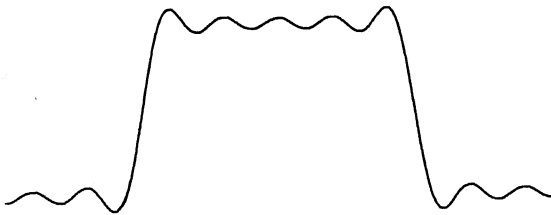
WHAT'S A FOURIER TRANSFORM, ANYWAY?

Dave Shaffer

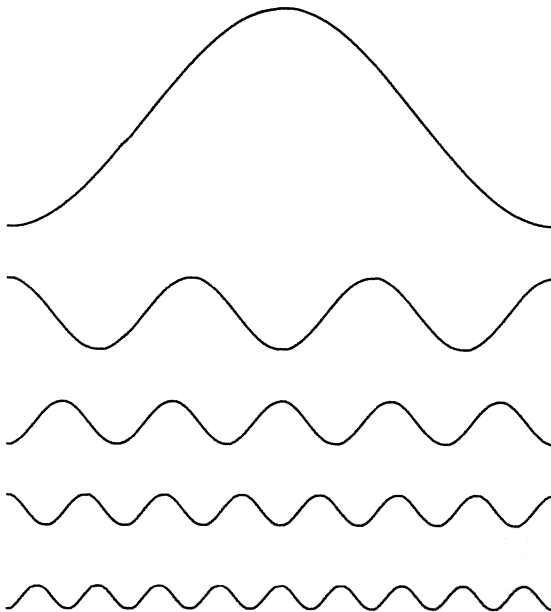
You may remember that the last two year-end issues of the *OBSERVER* featured the Fourier transforms of a Christmas tree (1976) and "NOEL" (1977) on the back cover. If you sneak a peek at the back of this issue, you'll see the transform of a star. These contour plots are something of an astronomical joke which I have been doing for the past few years. The joke relates to the fact that an interferometer (like the Green Bank system or the VLA) measures the Fourier transform of the radio image the astronomer would like to have. I send these plots as season's greetings to my (mostly astronomical) friends.

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The transform is named for Jean Baptiste Fourier, a French mathematician who lived from 1768 to 1830. The Fourier transform technique allows one to decompose a complicated image (a radio map in the case of interferometry) into a whole bunch of simple mathematical functions. (A mathematical function expresses the relationship between several quantities. For instance, the distance you travel in your car in an hour is a function of the speed of the car.) One of the nicest, simplest functions in mathematics is the sine function. The lower



The (almost) square pulse above can be represented by adding the five sine waves below.



part of the accompanying figure shows several sine functions, or sine waves as they are often called. Sine functions occur naturally in many phenomena - the motion of a swing or a pendulum is basically a sine function. Fourier analysis is based on a sine wave

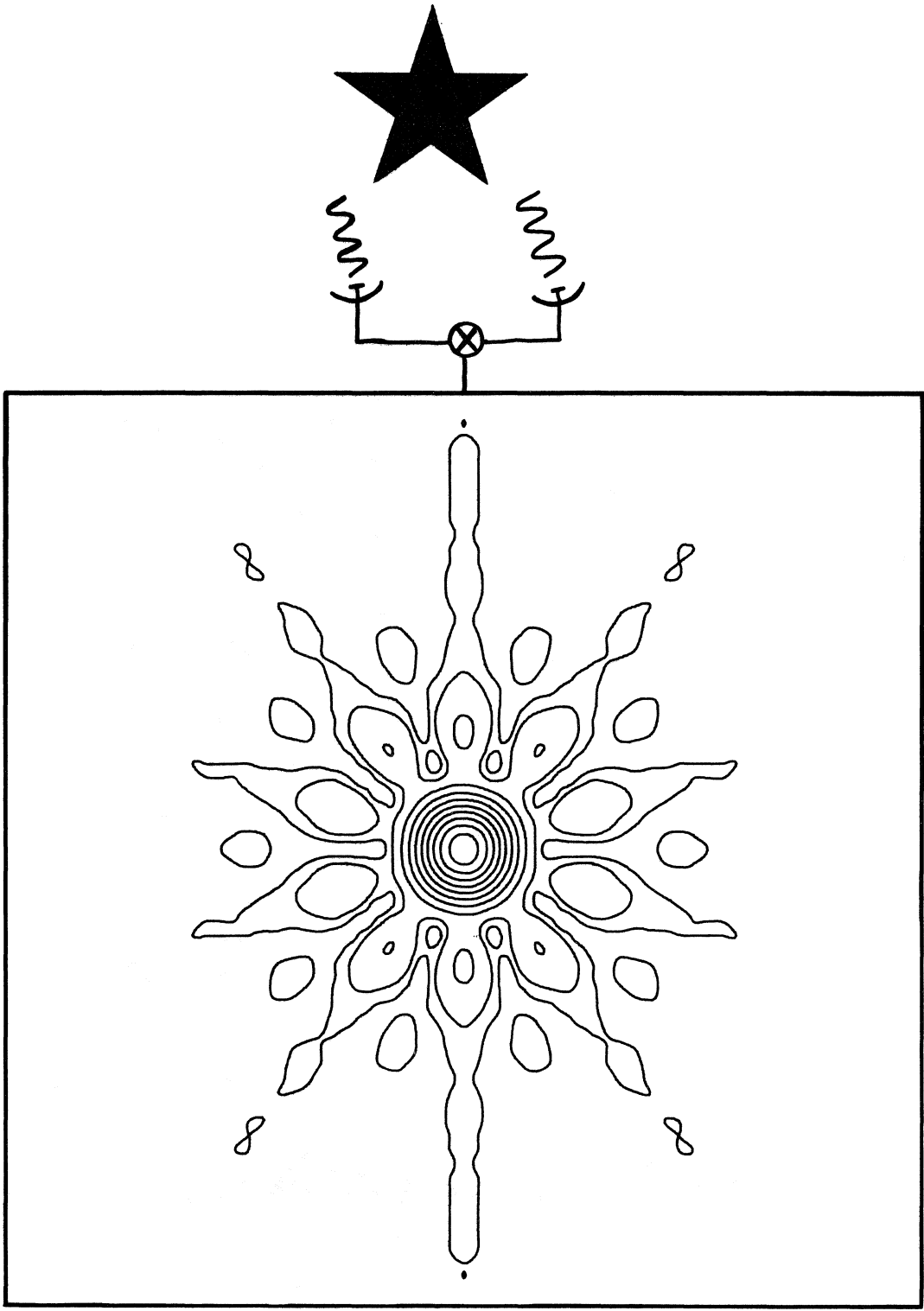
buildup of a complicated function, like perhaps the behavior of waves on the ocean. In the figure, I have showed how a square pulse can be adequately represented by a sum of just five simple sine waves. Each sine wave has a particular frequency (the rate at which it goes up and down) and amplitude (how far it goes up and down). One could get a better approximation to the square pulse by adding up more sine waves. The computation of these waves is straightforward, but may be rather tedious.

The contour diagram on the back cover is a plot that represents the amplitude of the sine waves in the Fourier transform of a five-pointed star as a function of frequency and position angle. The distance from the origin (the center of the plot) represents frequency. For an interferometer, the greater the spacing between the antennas, the higher the frequency it is measuring and the finer the detail in the source it can see. The position angle is just the angle measured clockwise, say, from the top of the figure.

Notice the symmetry in the plot. There is left-right symmetry (one side is the mirror image of the other side), and there is also what can be called reflection symmetry through the origin (a straight line drawn through the origin will indicate identical features as one goes outward from the origin in opposite directions). This property is universal for images of real objects, and means you really only need to measure half the transform in order to make a map.

For the technically minded, the input was a 33 x 33 grid. The 65 x 65 output grid was calculated by a brute force transform (5.5 minutes of 360 CPU time! That's why FFT's are better.) and plotted with the Calcomp contouring package.





SEASON'S GREETINGS
FROM OUR INTERFEROMETER TO YOURS

FOURIER TRANSFORM OF A STAR