



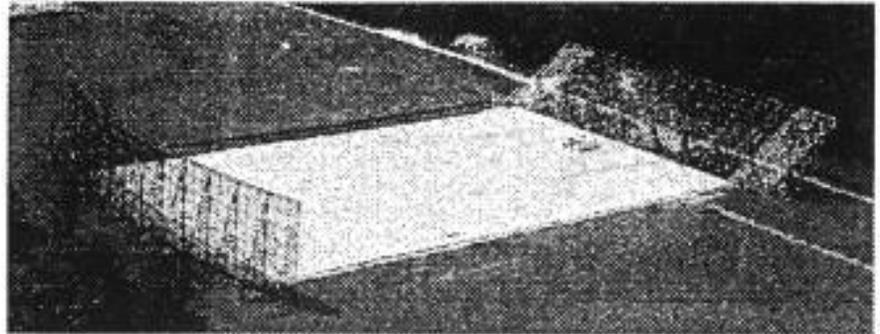
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SIGNALS



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
614-823-1516 (NAAPO)
4655 Indian Ct.
Westerville, Ohio 43082
614-882-6711 (home)

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CARL SAGAN, CORNELL ASTRONOMER, DIES DEC. 20 IN SEATTLE AT AGE 62

Carl E. Sagan, the David Duncan Professor of Astronomy and Space Sciences and director of the Laboratory for Planetary Studies at Cornell University, died Dec. 20, 1996, in Seattle, Wash., after a two-year battle with a bone marrow disease. The cause of death was pneumonia.

A public memorial will be held Monday, Feb. 3, 1997, at 2 p.m. in Bailey Hall on the Cornell campus.

Sagan, 62, was at the Fred Hutchinson Cancer Research Center at the time of his death. He had received a bone marrow transplant from the center in April 1995 for the treatment of myelodysplasia, a pre-leukemic syndrome.



Sagan continued to supervise undergraduate and graduate students and do research while recuperating from his illness, but returned unexpectedly to the Seattle hospital this month.

Astronomer, educator and author, Sagan was perhaps the world's greatest popularizer of science, reaching millions of people through newspapers, magazines and television broadcasts. He is well-known for his work on the PBS series *Cosmos*, the Emmy- and Peabody-award-winning show that became the most watched series in public-television history. It was seen by more than 500 million people in 60 countries. The accompanying book, *Cosmos (1980)*, was on The New York Times bestseller list for 70 weeks and was the best-selling science book ever published in English.

"The entire Cornell community mourns the loss of our colleague Carl Sagan, the David Duncan Professor of Astronomy and Space Sciences," said Cornell President Hunter R. Rawlings III. "A gifted scholar and researcher, Carl Sagan inspired

thousands of students here in Ithaca and across the world to open their minds to the wonders of science and the universe. Through his writings and television productions, he brought the excitement and challenges of scientific discovery into the homes of millions of families here and abroad. He used these talents effectively in the public sector, becoming a major force in support not only of planetary exploration but also in behalf of environmental protection here on Earth. We will sorely miss him, but his legacy at Cornell will last for generations to come. Our thoughts go out to his wife and collaborator, Ann Druyan, and the entire Sagan family."

Yervant Terzian, chairman of Cornell's astronomy department, said: "Carl was a candle in the dark. He was, quite simply, the best science educator in the world this century. He touched hundreds of millions of people and inspired young generations to pursue the sciences. He will be deeply missed by his colleagues and friends at Cornell and around the world."

Sagan has published more than 600 scientific papers and popular articles and is author, co-author or editor of more than 20 books, including *The Dragons of Eden* (1977), for which he won the Pulitzer Prize in 1978. The U.S. paperbound edition of his book *Pale Blue Dot: A Vision of the Human Future in Space* appeared on best-seller lists worldwide and was selected as one of the "notable books of 1995" by The New York Times. His reading of an abridged audio-cassette version was nominated for a Grammy and was cited by *Publisher's Weekly* as one of the "two best audiobooks of the year."

This year, he published *The Demon-Haunted World: Science as a Candle in the Dark* (Random House), which became Sagan's eighth New York Times bestseller. With his wife, Ann Druyan, he was co-producing a major motion picture from Warner Brothers based on his novel *Contact*. The movie is due to be released in 1997.

Carl Edward Sagan was born Nov. 9, 1934, in Brooklyn, N.Y. At Cornell since 1968, Sagan received a bachelor's degree in 1955 and a master's degree in 1956, both in physics, and a doctorate in astronomy and astrophysics in 1960, all from the University of Chicago. He taught at Harvard University in the early 1960s before coming to Cornell, where he became a full professor in 1971.

Sagan played a leading role in NASA's Mariner, Viking, Voyager and Galileo expeditions to other planets. He has received NASA Medals for Exceptional

Scientific Achievement and twice for Distinguished Public Service and the NASA Apollo Achievement Award.

His research has focused on topics such as the greenhouse effect on Venus; windblown dust as an explanation for the seasonal changes on Mars; organic aerosols on Titan, Saturn's moon; the long-term environmental consequences of nuclear war; and the origin of life on Earth. A pioneer in the field of exobiology, he continued to teach graduate and undergraduate students in courses in astronomy and space sciences and in critical thinking at Cornell.

The breadth of his interests were made evident in October 1994, at a Cornell-sponsored symposium in honor of Sagan's 60th birthday. The two-day event featured speakers in areas of planetary exploration, life in the cosmos, science education, public policy and government regulation of science and the environment — all fields in which Sagan had worked or had a strong interest.

Sagan was the recipient of numerous awards in addition to his NASA recognition. He has received 22 honorary degrees from American colleges and universities for his contributions to science, literature, education and the preservation of the environment and many awards for his work on the long-term consequences of nuclear war and reversing the nuclear arms race.

Among his other awards have been: the John F. Kennedy Astronautics Award of the American Astronautical Society; the Explorers Club 75th Anniversary Award; the Konstantin Tsiolkovsky Medal of the Soviet Cosmonauts Federation and the Masursky Award of the American Astronomical Society. He also was the recipient of the Public Welfare Medal, the highest award of the National Academy of Sciences, "for distinguished contributions in the application of science to the public welfare."

Sagan was elected chairman of the Division of Planetary Sciences of the American Astronomical Society, president of the Planetology Section of the American Geophysical Union and chairman of the Astronomy Section of the American Association for the Advancement of Science. For 12 years he was editor of *Icarus*, the leading professional journal devoted to planetary research.

He is co-founder of The Planetary Society, a 100,000-member organization and the largest space-interest group in the world. The society supports major research programs in the radio search for extraterrestrial intelligence, the investigation of near-

Earth asteroids and, with the French and Russian space agencies, the development and testing of balloon and mobile robotic exploration of Mars. Sagan also was Distinguished Visiting Scientist at the Jet Propulsion Laboratory in California and was contributing editor of Parade magazine, where he published many articles about science and, most recently, about the disease that he has battled for the past two years.

Sagan is survived by his wife and collaborator, Ann Druyan; his sister, Cari Sagan Greene; five children, Dorion, Jeremy, Nicholas, Sasha and Sam; and a grandson, Tonio.

A graveside service will be held Monday, Dec. 23, at Lakeview Cemetery in Ithaca. Shuttle buses at the Ithaca High School parking lot will be available for transportation to and from the cemetery starting at 1 p.m. Friends, colleagues and relatives will pay tribute to Sagan at the Herbert F. Johnson Museum of Art on the Cornell campus at 3 p.m. Contributions in lieu of flowers may be sent to the Children's Health Fund of New York, 317 East 64th St., New York, NY 10021, or The Planetary Society, 65 North Catalina Ave., Pasadena, CA 91106.

BOB DIXON'S ARGUS LIBRARY RESEARCH RESULTS

I have been spending lots of time in the Library searching journals and conference proceedings, and have found many relevant papers. Here are summaries of the best ones, and extensions of them I have made. Note that this does not necessarily change any current directions.

1. An array element other than a conical helix. This is a flat spiral, backed by a conical cavity. Most flat spirals are no good for **ARGUS**, because they either use an absorber cavity for wide bandwidth, or else they are narrowband because the cavity has a constant spacing behind the spiral. This antenna differs in that the spiral has a single arm that widens as it winds outward. The reflecting cavity behind it is a cone of very wide included angle (*maybe 160 degrees?*). It has no feeding problems, because a coax line is brought up thru the bottom of the cone, and the shield goes to the center of cone, and the center conductor passes thru a hole in the apex of the cone and connects to the center of the spiral. This paper seems to be little known because I have seen no subsequent references to it, and it is misclassified in the conference proceedings I found it in. Alas it became lost when I had my student xerox it, and we may never find it again. I am still trying.

2. Instead of arranging the array elements in a circle or spiral as we have discussed before, we can use the concept of subarrays. This means that you group the elements into closely spaced subarrays. For example, if we have 100 elements, we could group them into 10 small subarrays, and then locate the subarrays along a circle or spiral. I have known of this concept for some time, but did not feel that it was helpful to **ARGUS**, because the closely-spaced subarrays are not wideband by themselves, and they might have a pattern which restricts the sky coverage of the main array.

But now I found a paper which describes an array that we could adopt as an **ARGUS** subarray, that is truly frequency independent. It is very hard to visualize, but it is a three-dimensional log periodic array. The paper describes the use of dipoles with it, in a rectangular 3D grid, but I believe we could adapt it to use with slanting conical helices, in a concentric circular pattern. This would solve all the subarray problems and allow us to take advantage of some of the other subarray advantages. One of these is grating lobe control. If the pattern of the subarray is small enough to take out the grating lobes of the main array, then the problem is solved. A slanting conical helix is made by taking a normal one and deforming it to move the apex to one side so it is no longer over the center of the base. I have never heard of such an antenna, but I feel it will work, and slanting arrays of dipoles are used in the paper I found. I do not believe the array described in the paper can be made arbitrarily large, because its parts will start to run into one another within the 3D grid. But it should work well with a modest number of elements and hence as a subarray.

3. The use of subarrays in digital arrays to reduce the computing power required does not seem to be widely discussed (*at least I have not seen such papers, or perhaps I ignored them as I did not think that subarrays could be used with Argus*). But now I have done calculations to show that large savings in computer power can be achieved by using subarrays. The idea is like this: Suppose we have 100 elements in 10 subarrays. Each subarray has 10 elements and forms 10 fairly broad beams in the sky. One computer controls each subarray and forms the 10 beams. The 10 subarray computers send their sets of 10 beams each into a bank of 10 central computers. Each central computer takes the data from one of the broad beams from all 10 subarrays, and forms 10 or more smaller beams inside each one. So we end up with 100 or more beams. For this simple example, I calculate that we need only 1/5 the computing power we would need to calculate all 100 beams directly without subarrays. This approach also lends itself better to a distributed computing architecture.

I am working out the general laws which apply here. My preliminary results are that

the optimum subarray size is a constant times the square root of the total number of elements. And if you use the optimum size, the computational power needed is proportional to the total number of elements to the 1.5 power, as opposed to the conventional case where it is proportional to the 2.0 power.

In searching for further info on the 3D array I mentioned last time, I found a patent on it. This led me to searching for ALL patents related to aspects of the **ARGUS** project. I have found hundreds of them. But none of them duplicate what we are doing, and as academics, we can use all their results.

In the area of digital beamforming, there are patents on many clever algorithms for reducing the computing power, partial beamforming, interpolation, multi-stage, digital delays, error reduction, clipping, compression, geometric sampling and predetection signal identification.

There are lots on spiral antennas. Also circular arrays have many. Of particular interest right now are some which use the symmetry of circular arrays to reduce the computing needed thru mathematical techniques like Fermat Number Transform and Bessel Sequences.

Many of the patents are from US Government agencies, and may reflect behind-the-scenes research in progress. Many of the patents refer to other patents and to journal articles, so there is a seeming endless chain of information. I grow weary.

And this is only US patents. 1/3 of all patents in the world are Japanese. I tried to search Japanese and European patents but they have no free Internet access. You have to pay some company to do the search for you. (*Shows again how far ahead the US is in such things*). Canada also has an open search tool, and I found one useful patent there.

I have a big stack of patent abstracts now. I plan to order the full-text versions of the best ones, or look them up on the Library microfilm (*neither is attractive*).

SATURDAY, 12/21/1996 MEETING REPORT

By: Tom Hanson

Attending: Dr. Dixon, Cindy Brooman, Ang Campanella, Don James, Dr. Barnhart. The major event of this day was lowering of the Flag of Earth to half mast in honor and in memory of Dr. Carl Sagan.

Prior to the decision to embark upon this non-trivial task, Dr. Dixon reported on his proposal for **ARGUS** funding. According to Cindy Brooman, the proposal was written with the SETI Institute as the intended recipient, and it requests \$150,000 for **ARGUS**.

As a side note, the circuit breakers for heaters were set off in the Administration building, so the meeting room was extremely cold. It is not clear why anyone would have turned off the heat, but a sign requesting that the heat be left on was posted by the circuit breakers. Due to the risk of freezing of water pipes in the living quarters, doors in that section of the building were left ajar. The main hallway doors were locked as usual.

As predicted, a shipment of retired IBM PS/2 286 and 386 CPU's was delivered to the administration building. These systems are not guaranteed to work. On the other hand, they may work for years to come.

GALILEO MISSION STATUS

December 26, 1996

Data from last week's successful flyby of Jupiter's moon Europa by NASA's Galileo spacecraft are being radioed back to Earth on schedule, project officials report. "Everything is going normally on the spacecraft, and the return of the high-resolution images of Europa started on schedule yesterday," said Galileo Project Manager Bill O'Neil at JPL. Imaging data will be collected and processed over the coming days and weeks. Processing of the first of the images should be completed early in January and the images will be released shortly thereafter, O'Neil said.

Galileo flew past Europa at an altitude of only 692 kilometers (*about 430 miles*) from Europa on December 19 at 0653 Universal Time (*December 18 at 10:53 p.m. Pacific Standard Time*). Galileo flew more than 200 times closer to Europa than the Voyager spacecraft came to that moon in 1979.

Europa is especially intriguing because scientists believe it may have an ocean beneath its icy crust.

Throughout last week, Galileo made scientific observations of Europa and the other satellites, and gathered data on Jupiter and its magnetosphere through December 22. The observations included the closeup images, nighttime and daytime temperature measurements, searches for auroral activity, the magnetic field, atmospheric studies and investigations of the charged-particle environment in Europa's vicinity. Playback of data stored on Galileo's tape recorder will continue through mid-February, concluding just before Galileo's next Europa encounter.

The next Europa flyby will be even closer at an altitude of a mere 587 kilometers (*364 miles*) on February 19. The spacecraft's third flyby of Europa will occur on November 6, 1997, at an altitude of 1,125 kilometers (*699 miles*).

JPL manages the Galileo mission for NASA's Office of Space Science, Washington, DC.

DONATIONS RECEIVED

Tom Montgomery has donated \$50.00 to the cause in the form of a check, to help with *Signals*. He states in the note he sent along with the check that he still has his portable welding rig, and stands ready to weld things together for us should the need arise. He further promises to try to make it to one of the spring meetings.

Tom Hanson has donated several PC's to the cause. They have been delivered to the site, and await someone to make good use of them. If you know of any project that could benefit from the use of a PC, please contact Steve Brown or Russ Childers.

Have spare computers, parts, or cash lying around? You, too, may "donate to the cause". Simply contact either myself or Phil Barnhart to arrange pickup or an address to mail your donations to.

COORDINATOR'S CORNER

By: Phil Barnhart

A move is in the offing. Land for a one acre **ARGUS** is being negotiated. The **SETI** survey will continue.

Unfortunately the successful accomplishment of that search will not occur within the lifetime of one of the leading sparks in the effort to demonstrate we are not alone. Carl Sagan realized we as individuals are not immortal, but are part of what may well be an on-going, thriving, seemingly immortal stream of intelligence.

Indeed, if we are worth anything as individuals it is the influence we have to train and inform our acquaintances and students in the art of most effectively using this universal gift. Carl realized this key to education may very well extend to the limits of the universe. It is in the effective (*not always wise*) use of intelligence that makes a civilization (*warts and all*) like ours detectable across the light years.

Fare well, Carl. Happy voyage.

VOLUNTEER PROFILE: Ang Campanella



Ang Campanella

A volunteer who offers much more than technical training and accomplishment in higher education is an asset to any program needing a variety of inputs. Angelo Campanella brings to the radio observatory program the enthusiasm of a veteran solver of problems. He encourages movement when the rest of us sit contemplating the gloom of enforced change. He gladly bears the camera toting Coordinator aloft in his Mooney flying machine to get spectacular views of the observatory and surrounding acreage for publicity

purposes.

He also happens to be possessor of a PhD in Physics and Electrical Engineering from Penn State University. Occupied at the present as a consultant in acoustics, Ang came to the radio observatory through a combined interest in radio and astronomy. His contributions include, besides the flying circus, regular contributions to the working sessions, literature searches and the construction of a computerized strip chart recorder that continually provides a visible record of the continuum output of the telescope.

Ang claims to receive great satisfaction from working with the group. It is believed this to be sincere and not just to receive the delicious brownies served up at open house events. He cites the "... great group of avocational professionals ..." with whom he can associate.

He brings an optimism to our operation and sees the future as bright as long as we have functioning radio astronomy hardware on which to work. He is contributing significantly to assuring this will be the case as we move into the **ARGUS** era of radio astronomy. We all enjoy the pointed comments he drops onto the RO bulletin board serving the volunteers. Thanks, Ang.

SATURDAY, 01/04/97 MEETING REPORT

By: Tom Hanson

These notes begin at 10:15 A.M., with Dr. Dixon's monologue in progress. The notes were taken with a text editor, converted to Wordpad and then to Word, and then forwarded via Eudora. Formatting is a problem, which will be addressed in future notes.

Attending: Dr. Dixon, Dr. Barnhart, Ron Leeseberg, Ang Campanella, Earl Phillips, Cindy Brooman, Jerry Ehman, Ken Ayotte, John Ayotte, Jody McKean, Mike Brooks, Steve Brown.

Dr. Dixon: Goal for today – put flag back up again (*this was accomplished!*). Mail – software – Planet View – This DOS software was made available by the Challenger Center for Space Science Education. The Center is working on an updated version of the software. The current package supports observations from January 1, 1990, through December 31, 1999. Note: The Planet View package will be made available for distribution to Radobs members who come to the Administration Building, and who supply 3.5 inch 1.44 Mb diskettes. Shows pictures of where the planets are, or the moon is on any date within the range of the almanac, which is provided by the

US. Naval Observatory. MTSO Methodist Theological Seminary of Ohio – negotiations are continuing.

Marilyn McConnell-Goelz – has reviewed documentation under development. Discussion of Patent Law – Patent applications involve Disclosure and Claims. Some claims are normally eliminated during patent review process. Ang suggested we ask for permission to use patented technology. Dr. Dixon has sent email to patent holders already: Penn State University, Professor of Electrical Engineering, Paper seems vague, Professor has a personal web page.

Jody McKean – Completed Radobs roster with updates as of January 2nd. Jody sent a magnetic copy to Cindy Brooman, who placed in www.bigear.org for limited access. Dr. Barnhart will mail paper copies to the computationally challenged.

John Ayotte – no show and tell today. Studying articles about antenna design. No huge insights – confirmation of current direction. Doing computations to evaluate increasing number of turns to increase bandwidth. Dr. Dixon & Dr. Kraus has expressed an interest in this project. Dr. Kraus referred to a quotation in one of his books, in correspondence with Dr. Dixon. John Ayotte has checked to see what machines might be available at work, for fabrication of model **ARGUS** antenna designs. Apparently the largest lathe is too small to build the current design directly. Discussion – current goal is to build a prototype. Beyond that – there is the question of how to mass produce antennas. An unknown is whether the counter rotating turns can touch or must be insulated from each other.

Ken Ayotte – Made a temperature control for his receiver. Ken's receiver is housed in a Craftsman tool box, which is located outside near the antenna. The temperature control is performed by a computer. Voltage corresponding to temperature is converted to digital data. The computer turns on power to a resistor which is accompanied by a fan. Dr. Barnhart asked what is the range of temperature variation? Ken – not sure, but received data is coming out a lot better. Remapping part of the sky already mapped to see if there are changes. One of Ken's pre-amps is oscillating badly, so he took it out.

Mike Brooks – working on RFI program & Emailing with Dr. Dixon. Thresholding was a source of frustration – he did something about it! Mike just included a chunk of code to make a better guess on where to start the threshold, and it seems to be working. Note – Lucent is hiring like crazy right now – looking for wireless

engineers. HP workstation may be available for donation. Mike will investigate further.

Jerry Ehman – Offered Dispatch article on Flag of Earth at half mast & December 28th – Dispatch – article on optical observatories, Tom Burns – article on Carl Sagan – Jerry gave a favorable review, February Sky and Telescope – read article pointed out by Ron Leeseberg, which expressed concern that humans should avoid alerting any potentially unfriendly aliens to our presence. Note: I have read the article as well, and my impression is that it is well reasoned. The author includes most of the arguments of those who would be on the other side of the discussion, although he does refer disparagingly to such persons at several points. Files from Dr. Dixon failed to unzip – Jerry asked for original source and downloaded the files, but he has not had time to try to unzip them.

Cindy Brooman – Reminder of movie under development – "Contact" by Carl Sagan. Dr. Kraus informed Cindy that the studio had ordered two copies of each of his books for background material. Cindy recorded 3,359 document requests for December at Big Ear web site. Earl Phillips volunteered that he may have contributed a number of those hits. 20,000 hits per month are coming into Cindy's site overall. Re-reading forward which Dr. Dixon wrote for a book. She inquired if it might be all right to place this article on the web site. Dr. Dixon granted permission for the posting. Cindy now has copies of photographs suitable for scanning, thanks to assistance from Dr. Barnhart, in converting from photograph to hard copy. Thanks will be extended to Herb Johnson for his contribution to this initiative.

Earl Phillips – a check has arrived from a Mr. O'Conner, who did some welding for Radobs. Mr. O'Conner offered to assist the facility with welding in the future, if needed. Earl requested more articles for *Signals*. Discussion of the demise of Incredible Universe, a Tandy retail chain. Cindy recommends Columbus Microsystems for knowledgeable staff.

Tom Hanson: Renewed his request for assistance in changing the password for access to Homenet. In discussion, it appears that no one else present ever changes their password. Dr. Dixon suggested this address for help with password problem.

Ang Campanella – Discussed Walt Whitman poem in reference to Carl Sagan. Dr. Barnhart – Carl Sagan – book: *Cosmic Connection*. Discussion of Carl Sagan's legacy. Dr. Barnhart suggested at least one area of theoretical astronomy where Dr.

Sagan's contribution may have lasting impact. Dr. Barnhart reported that a number of students entered his classes because they had watched "*Cosmos*" on PBS. Dr. Sagan spent a great deal of time at JPL, working with scientists operating the Voyager and other probes. Dr. Dixon has attended conferences also attended by Dr. Sagan. Dr. Barnhart emphasized that Carl Sagan's classes at Cornell University were always popular and well attended. Note: This report includes complimentary views which were expressed about Dr. Sagan. Ang is willing to help with the fabrication of the helix, when the time comes. Dr. Dixon is still trying to find an article he found and then lost. The original search was done on-line, and he would prefer not to do that again. Mike Brooks asked what range of dates Dr. Dixon had covered. Dr. Dixon simply explained that he ordered whatever the library had. Ang Campanella asked about the article. Apparently the smaller windings are closest to the ground plane, and the larger windings away from it. This is the reverse of the current **Argus** antenna concept. Dr. Dixon said that the feeding of the antenna was unusual and that it seemed to have attractive qualities. John Ayotte reported that he had received a copy of a study done by a researcher who had extensively investigated cylindrical helices.

Ron Leeseberg – Thanks to Jody McKean for member list. Question about the comet due to arrive soon. Dr. Barnhart replied that the comet has already developed a tail. Ron expects to leave for Florida at the end of January. Ron expects to have a class for his astronomy course, to be held during January. He described a forthcoming paper on doing **SETI** at 10 GHz.

Earl Phillips – freed up 1200 floppy diskettes, by converting to Zip Disks. Dr. Barnhart suggested they be brought to the RO.

There was discussion of the long term need to give up space at Dreese Hall. This led to discussion of the card project. Dr. Dixon was required to move boxes of cards in the storage room, to meet requirements for ceiling clearance imposed by the OSU Fire Marshall. There is need for a volunteer to take on the position previously filled by Joe Mitchell, to edit the reconciled card data in preparation for writing the final CD-ROM disk. Following the meeting, Ron Leeseberg expressed interest in helping to move the ball forward. There is a need for a "Final CD-ROM Editor", to replace Joe Mitchell, who left Columbus to attend graduate school at Case Western in Cleveland.

Steve Brown is working on his thesis. He's been trying to make measurements of

strong signal performance of our receiver system. This relates to the planned Motorola satellite system, which is expected to use frequencies in and around the Water Hole.

BIG EAR WEBSITE IS A POPULAR SPOT

By: Cindy Brooman

The Big Ear Website (www.bigear.org), launched in October of this year, has been surprisingly successful in attracting visitors. The site recorded 3,591 document requests for the month of November, and 3,359 document requests during the month of December! For a new Internet site that advertises itself only through search engines and by word of mouth, these numbers are quite high.

Planned additions to the site in the near future will include images from slides, photographs and diagrams. The images will complement the existing text. Thanks to Herb Johnson for lending his slide set, and to Phil Barnhart for entrusting the Webmaster with his notebooks full of photographs and diagrams.

FLAG OF EARTH CREATOR HONORED SAGAN NEVERTHELESS

By: David Lore

Dispatch Science Reporter

The Flag of Earth flew at half-staff at extraterrestrial search sites around the world this week in memory of Carl Sagan, although the late astronomer reportedly had refused to endorse the banner.

"I really wanted him to back the flag," said its creator, James Cadle, a 60-year-old factory worker from St. Joseph, Ill. "I didn't care for any monetary reward, but it would have been nice, because I loved *Cosmos* and I've got all his books."

The flag, which flies over the "Big Ear" radio telescope near Delaware, Ohio, was first made by Cadle in 1970 to represent all mankind. Inspired by Earth Day demonstrations and the Apollo 11 moon landing, Cadle sewed the flag and stuck it on a rural power pole, where it soon caught the attention of other space enthusiasts. Simplicity itself, the Flag of Earth is three spheres — a gold sun, a blue earth and a silvery moon — on a canvas of black. It was designed to remind all people that they share one beautiful but fragile planet, and to locate the Earth for any extraterrestrials we may encounter some day.

"My flag," Cadle said in a 1987 interview, "would tell them we have a yellow sun, a blue planet and that we're the only planet in the system with one, over-large moon."

According to Robert Dixon, assistant director of the radio telescope in Delaware, Cadle's flag flies at telescope sites around the world involved in the Search for Extraterrestrial Intelligence program. It flies at SETI league headquarters in Little Ferry, N.J., and it is often unfurled at space science and science fiction conventions. "Cadle created this flag to be used for any purpose representative of humankind as a whole," said Dixon. "It's independent of any individual or organization or country, so it requires nobody's approval to use."

Sagan, who died Friday, Dec. 20, 1996, was the author of the novel *Contact* and produced *Cosmos*, the award-winning 1980 PBS series. He also was an important force in keeping the struggling **SETI** program alive in the face of congressional skepticism, and was co-founder of the California-based Planetary Society, which strongly backs the search for life beyond Earth.

Cadle said he never talked directly to Sagan, but he heard from others that the astronomer wouldn't endorse his flag as a symbol for the search. "They didn't say he didn't like it," said Cadle. "He just wouldn't back it."

Louis Friedman, executive director of the Planetary Society, has said any banner purporting to represent all mankind should be developed through international dialogue. Cadle, however, thinks that's unrealistic. "How in heaven's name are you going to get a committee to agree on something like that?" he asked.

The flag has never been mass-marketed; Cadle said he sells about 20 or 30 a year, "and the only person who sells it is me." Shortly after the turn of the century, Cadle said, he plans to retire from his job at a window sash plant and pack his suitcase. "I intend to travel to all those places" where the flag is flying, he said. "I'm going to do it all."

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MOONS MAY HARBOR LIFE

Mysterious gassy planets spotted outside the Earth's solar system may not be hospitable to life as we know it, but rocky moons orbiting them might, U.S. scientists said Wednesday.

Darren Williams and colleagues at Pennsylvania State University said they had identified two systems that might have planets with such moons.

"Such a moon would ... need to be large enough to retain a substantial and long-lived atmosphere, and would also need to possess a strong magnetic field in order to prevent its atmosphere from being sputtered away by the constant bombardment of energetic ions from the planet's magnetosphere," they wrote in a letter to the science journal *Nature*.

There are precedents. Jupiter's moons Io and Europa have water and Earth-like atmospheres, Ganymede has a magnetosphere while Saturn's moon Titan also has a measurable atmosphere.

A habitable moon would also have to be more than 10 percent the mass of the Earth in order to hang on to its atmosphere, Williams's group said. The Earth's moon is less than one one-hundredth its mass.

"All this suggests that the systems belonging to 47 Ursae Majoris and 16 Cygni B should be considered as possible abodes for extraterrestrial life," they wrote.

Nine probable planets have been spotted outside the solar system, but they are all large and presumably either brown dwarfs — small, cold suns — or large gassy planets like Jupiter. Neither would support life by current definitions.

Christopher Chyba, a planetary scientist at the University of Arizona, said in an accompanying commentary that it would be decades before scientists had the technology to spot Earth-sized planets more likely to support life.

BLACK HOLES MAY LURK AT THE CENTER OF MOST GALAXIES

Two separate groups of astronomers reported "almost incontrovertible" evidence that black holes not only do exist, but probably lurk in the center of nearly every galaxy — including the Milky Way.

Both groups, who presented their findings at the American Astronomical Society meeting in Toronto, expect that, finally, even their skeptics will be hard pressed to find an alternative explanation.

Douglas Richstone and Karl Gebhardt of the University of Michigan in Ann Arbor have developed a computer model that analyzes how fast the stars of a galaxy are observed to orbit around its center.

They have discovered three galaxies that carry what they call "the fingerprint of a black hole." "We look for stars that are orbiting faster and faster as you get near the center of the galaxy," said Gebhardt.

Gebhardt said their conclusions are hard to dispute because the Michigan model replaces many of the assumptions that previous models had to make with actual observations. Skeptics in the past, for example, have argued that close-in stars merely appear to orbit faster because they are actually plunging either toward or away, not around, a galaxy's center.

"We're finding a black hole (in the middle of a galaxy) pretty much everywhere we look," Richstone said. "And if you count up the black holes ... and compare that with the density of quasars in the early universe, the numbers match."

That match is significant, Richstone said, because many astronomers believe yesterday's quasars — objects not much larger than the sun but a trillion times brighter — are today's black holes.

The other group of astrophysicists, who work at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., have observed nine pairs of nearby stars in which one is pulling gas away from the other. As the gas swirls in, it becomes faster and hotter.

Ramesh Narayan and his colleagues know that the massive object in five of the nine

pairs is a neutron star, the ultra-dense remains after the collapse of a large star. The energy from the streaming gas makes them brighter, as they predicted.

But in the four remaining pairs, the massive object is much dimmer. The energy seems simply to disappear. Thus they can't be neutron stars, Narayan said, as skeptics have suggested earlier.

"Our data show that these (objects) are black holes because they have an event horizon, we're seeing a strong indication of energy disappearing into the objects".

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Designed by Jerry Ehman

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