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IN THIS ISSUE:

ed. note:

The RO is still in a state of flux regarding our lease negotiations. If you have volunteered efforts, materials, or time to the cause, please let us know. Also, if the spirit moves you, please write to the powers that be and let them know your opinion. We have weathered such storms in the past because of the overwhelming friendship of our supporters; we will do so again!

Thank You!

SPACE ENTHUSIASTS CAMPAIGN TO KEEP TELESCOPE SEARCHING

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SPACE ENTHUSIASTS CAMPAIGN TO KEEP TELESCOPE SEARCHING
By: Dave Lore, Columbus Dispatch Science Writer

As predictable as Halley's comet, the "**Big Ear**" controversy is again orbiting *Ohio State University* as the lease expires on the university's huge radio telescope near Delaware, Ohio.

"I am appalled to hear that this historic telescope is still under threat," said *Arthur C. Clarke*, a science fiction writer, in a Jan. 27 letter to **OSU President Gordon Gee**. "I hope you will be able to preserve an instrument which has perhaps done more than anything else to make your University famous throughout the world!"

The radio telescope, built in the 1950s and bigger than three football fields, was the first to begin continuous monitoring of signals from space and thus is something of an icon among supporters of **SETI**, the search for extraterrestrial intelligence.

A number of **SETI** scientists and supporters have written Gee about the telescope, including *Cornell University* astronomer *Carl Sagan*.

"I've heard from everybody from 8-year-olds to some very high-level people," said William Baeslack, an associate dean of engineering involved in the lease negotiations. "Obviously this is a high profile issue, and it will get a lot of press, and a lot of people will be interested."

In 1983, **Green Highlands**, the development group that owns the telescope's 24-acre site east of Rt. 23, south of Delaware, stirred a fuss by trying to evict the observatory to expand an adjacent golf course. Students staged fundraisers, a **Save the Telescope Committee** was organized and publications around the world wrote about the showdown between golf and galactic science.

A settlement in 1985 gave OSU a 10-year lease, with the right to renew in 1995 for another 10 years. The original term expires July 31. OSU likely faces an increase on its $9,000 yearly lease because of new property appraisals. What's hanging up negotiations and causing tremors among telescope supporters, however, is a lease clause requiring OSU to give the 24,000 square-foot instrument a fresh paint job — preferably in golf course green — upon renewal.

That could cost as much as $285,000, more than the original cost of building the two giant reflectors, said *John Kraus*, the professor emeritus of engineering who built the telescope, named it "**Big Ear**" and in retirement serves as director of the **OSU Radio Observatory**. Kraus said the $285,000 estimate was based on special problems involved in removing the old lead-based paint from the two reflectors. The reflectors, which face each other across a 3.5-acre aluminum ground plane, are towering structures, 70 and 100 feet high and 360 and 340 feet across, respectively.

OSU has given Green Highlands formal notice of its intention to renew, but Baeslack said no options – including cancellation – have been ruled out. One possibility, for example, is that OSU might agree to abandon the telescope before 2005, providing Green Highlands pays for the paint job or waives the requirement, Baeslack said.

Richard Farr, principal partner in Green Highlands, could not be reached for comment yesterday. "This comes at a particularly bad time," said *Robert S. Dixon*, assistant director of the observatory. New equipment has recently been installed, he said, and an expansion of activities on the site is possible. "This has somewhat of a chilling effect if the research sponsor can't be sure we'll continue what we're doing," said Dixon.

Funding to search for extraterrestrial intelligence was eliminated by Congress last year, Dixon said, but OSU has applied to **NASA** for about $500,000 to build a new type of radio telescope on the site: an array of computer-linked, mini-receivers that could operate concurrently with the old-style Kraus telescope.

Dixon and Kraus have also been talking with the **U.S. Geological Survey** about installing seismographs on the site to tie Ohio into the **U.S. National Seismograph Network**, an earthquake detection grid.

The radio telescope is currently used by students in the **OSU Electroscience Laboratory** as well as by students at other area colleges.

Volunteers continue to pursue programs to catalog natural radio sources – such as stars and galaxies – and monitor 4 million channels for signals from extraterrestrial civilizations, Dixon said.

"Even if it decommissioned, it should be preserved as a national monument, like the gantries at Cape Canaveral," Clarke wrote to Gee. "The discoveries it has already made should act as an inspiration to the rising generation, and perhaps help to turn back the tide of anti-intellectualism which threatens to engulf the Western world in a new Dark Age of neo-barbarism," Clarke said.

SATURDAY, 2/18/95 MEETING REPORT
By: Tom Hanson

We had a nice turnout for this meeting. Going around the table: Dr. Dixon, Dr. Barnhart, Bill Brown, Joe Mitchell, Jerry Ehman, John Ayotte, Ken Ayotte, Russ Childers, Mark Sundstrom, Dan Fleish, Don James and Steve Brown.

Canadian TV crew is coming on Monday morning. Anyone who would like to join the walk through is welcome to do so. The crew is expected to arrive at 8:30 AM.

The **Flag of Earth** pole was repaired after the meeting, in a scene reminiscent of the flag raising at Iwo Jima, 50 years ago. Don James assisted in loosening stubborn rusted hardware, using improvised tools and techniques. Steve Brown handled the final flagpole mounting, perched on a ladder held steady by several stalwart observers.

Dr. Klein's **World Wide Web Radobs Home Page** came in for more discussion. It had been proposed to place electronic copies of "*Signals*" there, but recent feedback has sensitized everyone to the possible consequences of distribution of some items. The current hardcopy distribution of "*Signals*" reaches friends of the **Observatory** who deserve and appreciate more information about ongoing issues than would be appropriate for a 'global' distribution. Accordingly, only selected items will appear on the *Home Page*. In addition, copywritten material will not be included, but instead, reviews of such materials will be provided. John Ayotte volunteered to provide such reviews.

Dr. Barnhart reminded us of Chris Slack's contributions two summers ago, when he visited the **Observatory** as a summer intern. Chris recently inquired about opportunities. Dr. Barnhart is actively investigating the possibility of drawing from a fund set up for just this sort of activity. If Chris were to visit us this summer, I have raised my hand in hopes he might be interested in the mini-project of interfacing our old IBM keypunch to a PC, in order to reread suspect boxes or trays. My proposal is that we capture the readings of the keypunch reading station in TTL logic circuitry, and then read the captured values in two bytes for transfer to a PC via serial or parallel interface. A simple basic program on the PC can store the data appropriately, and control the operation of the keypunch.

Dan Fleisch has been travelling extensively. He expressed interest in having a **Radio Observatory** electronic mail account, and it was suggested that he contact Paul Hurm. His CompuServe account has been overflowing due to a limit on the number of messages, and in any case, it was agreed that Dan's support of the **Argus** initiative certainly justifies asking for a *Magnus* account. Dan heard back from the *Defense Department*, in response to one of the **Argus** proposals he submitted. The proposal will not be funded in this cycle, but Dan expects to receive useful feedback in a forthcoming debriefing. Dan wrote his doctoral dissertation on the use of specialized radars for wind shear measurements. He indicated that an **Argus** type system would be an appropriate solution for this type of problem.

Mark Sundstrom has been analyzing continuum data which he received from Russ Childers two weeks ago. He is working on code to permit real time displays from incoming continuum data. He indicated interest in assisting Russ Childers with his request for information about the moon and planets, now that the telescope is working near the ecliptic.

Russ Childers announced that the telescope is positioned at 19 degrees, 20 minutes, or 43% through a complete survey. Russ reminded us of his interest in knowing when various bodies will appear in the beam. He said that a recent passage of the moon through the beam was fortuitous, because it provided a "nice small signal" for evaluation of modifications he has made to his pattern search algorithm. 2900 of 3000 channels detected the moon. 100 channels are permanently filled with noise or otherwise disabled. Russ's report generated a discussion of use of the *Listserver*, and a review of the history of electronic mail use by **Radio Observatory** members. Dr. Dixon suggested that after current uncertainties are resolved, the organization should spend some time trying to set a new standard for basic electronic mail capability.

John Ayotte has been extremely busy with his job. He now has access to two unix (*IBM's AIX*) workstations at work, which include even more powerful rendering capabilities than he has previously demonstrated. He offered to assist Dr. Barnhart in preparation of overhead slides for a presentation in May, at the *International Space Development Conference*, to be held in Cleveland. John's report led to discussion of ways in which **Observatory** staff and members might begin developing plans for a transition to **Argus** as the group's mission. It appears there may be University owned land west of Columbus, which might be suitable for

Argus research.

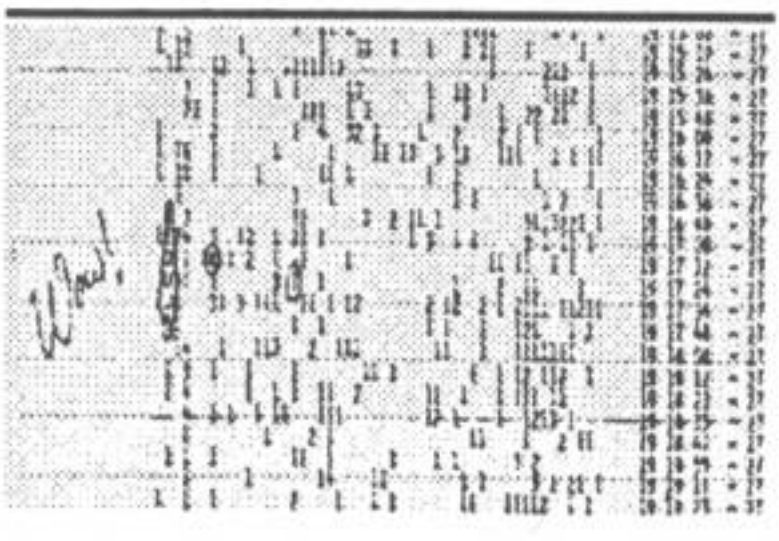
Ken Ayotte is working on an article for his 10th grade journalism class, and he is considering doing a report about the status of the **Observatory** lease renewal and related issues.

Joe Mitchell is continuing to move forward with his exploration of **Card Project Phase II**, which will result in a CD rom disk containing fully verified, annotated, organized **Observatory** data. John Ayotte offered to lend Joe a 5.25" disk drive and bus card for Macintosh, which would allow Joe to begin work using his Mac.

Herb Johnson and Joe have made contact, and Joe asked for a copy of Herb's recent work, listing the boxes and trays from **Card Project Phase I**. Steve Brown offered to provide a copy of the file.

Steve Brown has been investing most of his time working on **Serendip**. He deferred to Bill Brown, for most of the report. Bill described their efforts to understand **Serendip** by introducing an artificial signal. Experiments were performed with the frequency synthesizer, and it was discovered that certain settings of the synthesizer result in 200K error output. **Serendip** clearly pointed out these errors. Steve said that it appears that **Serendip** is subject to a problem, in which strong out-of-band signals can cause aliases.

Jerry Ehman heard from Herb Johnson, in response to his recent posting of information about the 1983 studies. Jerry is working on programs which might improve capabilities for discoveries of relationships between separate observations. He described the work as academic at present, but that it might ultimately have application on search strategies such as **Lobes**.



HUBBLE FINDS OXYGEN ATMOSPHERE ON JUPITER'S MOON EUROPA

Astronomers using **NASA's Hubble Space Telescope** (*HST*) have identified the presence of an extremely tenuous atmosphere of molecular oxygen around Jupiter's second moon, Europa. The planets Mars and Venus are the only two other solar system objects beyond Earth known to have traces of molecular oxygen in their atmospheres.

This detection was made by a team of researchers at the **Johns Hopkins University** and the **Space Telescope Science Institute**, both in Baltimore, and is reported in the Feb. 23 issue of the journal "**Nature**".

Europa's oxygen atmosphere is so tenuous that its surface pressure is barely one hundred billionth that of the Earth," said Principal Investigator Doyle Hall, of Johns Hopkins. "If all the oxygen on Europa were compressed to the surface pressure of Earth's atmosphere, it would fill only about a dozen Houston Astrodomes. It is truly amazing that the Hubble Space Telescope can detect such a tenuous trace of gas so far away."

Scientists had predicted previously that Europa might have an atmosphere containing gaseous oxygen, but had to wait for Hubble's sensitive instruments for confirmation. The HST researchers caution that the detection should not be misinterpreted as evidence for the presence of life on the small, frigid moon. Located 490 million miles (*780 million kilometers*) from the Sun, Europa's surface is too cold, measured at -230 degrees Fahrenheit (*-145 degrees Celsius*), to support life as we know it.

Unlike Earth, where organisms generate and maintain a 21% oxygen atmosphere, Europa's oxygen atmosphere is produced by purely non-biological processes. Europa's icy surface is exposed to sunlight and is impacted by dust and charged particles trapped within Jupiter's intense magnetic field. Combined, these processes cause the frozen water ice on the surface to produce water vapor as well as gaseous fragments of water molecules. After the gas molecules are produced, they undergo a series of chemical reactions that ultimately form molecular hydrogen and oxygen. The relatively lightweight hydrogen gas escapes into space, while the heavier oxygen molecules accumulate to form an atmosphere which may extend 125 miles

(*200 kilometers*) above the surface. The oxygen gas slowly leaks into space and must be replenished continuously.

Europa is approximately the size of Earth's Moon, but its appearance and composition are markedly different. The satellite has an unusually smooth and nearly craterless surface of solid water ice. Mysterious dark markings crisscross the surface, giving the moon a "cracked eggshell" appearance. Under the apparently fragmented icy crust, tidal heating by Jupiter might heat the icy material enough to maintain a sub-surface ocean of liquid water.

Of the 61 identified moons in the solar system, only three other satellites are known to have atmospheres: Jupiter's volcanically active moon Io (*sulfur dioxide*), Saturn's largest moon Titan (*nitrogen/methane*) and Neptune's largest moon Triton (*nitrogen/methane*).

The definitive detection of Europa's tenuous atmospheric oxygen was made possible by the ultraviolet sensitivity provided by HST's **Goddard High Resolution Spectrograph** (*GHRS*) instrument. The GHRS recorded the spectral signature of molecular oxygen (*O2*) on Europa in ultraviolet light during observations made on June 2, 1994, over a period of six Hubble orbits. Europa was then at a distance of 425 million miles (*684 million kilometers*) from Earth.

The Hubble observations will be invaluable for scientists who are planning close-up observations of Europa as part of NASA's **Galileo** mission, which will arrive at Jupiter in December 1995. During its initial entry into the Jovian system on Dec. 7, Galileo will fly by Europa at a distance of less than 22,000 miles (*35,000 kilometers*).

*The **Hubble Space Telescope** is a project of international cooperation between **NASA** and the **European Space Agency**.*

PULSARS AND SETI: COMMON GROUND?
By: Herb Johnson

In January 1995 I had the pleasure of attending a lecture at *Princeton University* by **Dr. Russell Hulse** on his Nobel Prize winning discovery of a binary pulsar. He happens to be a member of my astronomy club which sponsored the lecture, and he was a radio astronomer, so my interest was particularly strong. Sometime later in late January, Angelo Campanella reported that he saw an article in the January '95 "*Penn Stater*" about pulsar research by astronomer **Alexander Wolszczan** conducted at **Arecibo**.

The research suggested two or three planets were orbiting a pulsar. Angelo speculated "so another aspect of **SETI** might be some observations of pulsar rates...?". Later in discussion, Bob Dixon suggested in response that "We tried this once unsuccessfully, but if someone were interested we could try again. The average flux densities noted in Herb's list [*of pulsors within in our recent survey*] are small, and if we scale them down [*from 400 MHz*] to our freq of 1400 MHz, none of them are strong enough to be detected in our normal observing runs. "The problem", Bob continued, "is that pulsars emit pulses, not continuous signals, and hence their average strength is small. One needs a receiver/computer to do multiple averaging at the pulsar rate, to bring it out of the noise. Then if we were to track a pulsar position, we could probably detect it." However, former **Observatory** engineer Jim Bolinger noted some receiver limitations: "Remember that, first, the Dicke switch switches at about 79 Hz. Second, the square law detector output is proportional to the total power being received. Third, the output is integrated over a LONG time period compared to the Dicke switch rate, not to mention the pulsar rate." All these, particularly the third point, would almost certainly remove any pulsar events from the received radio signal.

This was part of a lively discussion, both in the *Internet* newslist and at some of the **Observatory** meetings, on pulsars and how they might be detected, either in our old and current data; or in any future survey work. In particular we discussed mathematically modeling pulsar behavior, and our resident and non-resident engineers spoke about the limits of our current methods or capabilities of new equipment. Since I provided information about pulsars in the *Internet* discussion and encouraged such research, I thought I'd summarize pulsar physics and its relevance to **SETI** for *Signals*.

WHAT ARE PULSARS?

Briefly, pulsars are rapidly rotating neutron stars with a small surface feature that produces a narrow emission beam of a few to several degrees in angular diameter. When this beam on a rotating star happens to pass in our direction, we see a "pulse" of radio (*and in some cases IR or optical*) activity. The striking feature of these emissions is their absolute regularity. Pulsars typically produce a pulse every millisecond to a few seconds or so, repeatable down to the tens or hundreds of NANOSECONDS per year. This suggests a repeatability in parts per billion (*10E9*) that is comparable to atomic clocks!

The stability of pulsar emissions is a consequence of their creation: the compacted remnants of a nova, supernova or similar explosion of matter. By conservation of angular momentum, when the material that is not blown off collaspes down to the density of "neutron soup", the rate of rotation speeds up. This rotation is stable but slows down over millions of years. Likewise, the magnetic field of the original star collaspes as well, its conservation creating an enormous magnetic field near the pulsar. Over millions of years, the drag of the magnetic field and other forces slows the pulsar down. Pulsars apparently stop emitting at some point, as few of them have periods longer than a few seconds.

There have been several hundred pulsars detected since their initial discovery in the mid 1960's, and particularly by more sensitive telescopes such as **Arecibo** and at the **NRAO** observatories.

... and why are they so interesting?

The most interesting feature about pulsars is their regularity. But pulsar emissions provide astrophysicists with a unique probe of the galaxy, a way to test Einstein's special relativity, and as a physics laboratory for extreme physical conditions.

Pulsars emit radio pulses across a wide bandwidth, which typically peaks around a few hundred Megahertz but which extends up to a few Gigahertz (*including our band of 1400-1600 MHz*). However, the medium of space between us and the pulsar — the interstellar medium — contains gases in thin but sufficient concentrations that delay the pulses at lower frequencies. This phenomena is called "dispersion". Consequently, by measuring this delay we have some information on the materials

and their density in interstellar space. In fact, dispersion is used as a pulsar "signature" to discover additional pulsars.

Pulsars emit from a very small portion of their surface, an area typically measured in kilometers. (*The physics and mechanisms for such limited and powerful emissions is not clear*.) The very physically narrow beam that is produced is more easily distorted by the interstellar medium than a wide beam or the general emission of an entire star. Therefore pulsars will "twinkle" or scintillate just like stars do to us on Earth through our "terrestrial" medium of air. (*Likewise, planets do NOT scintillate because they are visually much larger than stars.*) This scintillation provides a clue to changes in the interstellar medium between us and the pulsar, as pulsars "twinkle" over periods of days, months, and years.

Pulsars are so regular, so massive, and so fast in rotation, that they also provide an opportunity to examine the extreme effects of these conditions. Such effects are predicted by Einstein's special theory of relativity. An important testing ground was discovered by **Hulse and Taylor** at **Arecibo** in the mid 1970's: the first BINARY pulsar. A massive orbiting body, with an orbital period of several DAYS, provided tests of objects in motion at near-relativistic speeds. It produced small changes in the period of the pulsar which, under more normal conditions would be too small to detect. However, the ultrastable pulse period of the pulsar allowed Taylor to predict and verify these relativistic effects. Their efforts were recognized in 1994 by the Nobel Committee who gave them both a Nobel prize in Physics.

Angelo's reference to finding planets is also a consequence of the stability of pulsar emissions. Even the slight perturbing effects of a massive planet in orbit about a pulsar will produce Doppler shifts in period that can be detected and measured.

Pulsars also provide a lot of information about themselves. Changes in shape and amplitude in pulsar pulses and their fine structure (*called micropulses*) provide information on the processes that create those pulses. The magnetic field of the pulsar is enormous, typically 10E12 Gauss,which creates strongly polarized emissions that are a measure of that field. No artificial laboratory can (*easily*) create the intense magnetic, gravitational and thermal environment of a pulsar.

WHY SHOULD SETI BE INTERESTED IN PULSARS?

Briefly, I would suggest that pulsars have many of the qualities of a **SETI** transmitter. These two phenomena are (*or would be*) periodic, narrow in beamwidth, and modulated (*varying in amplitude in a regular fashion*). **SETI** signals are more likely to be narrowband in frequency, however, to save power and to be unique. While pulsars are not "frequency modulated", measurements of dispersion delay with frequency have some of the characteristics of such modulation.

These similarities suggest a more pragmatic reason to look for pulsars. Since our equipment and our antenna is potentially capable of seeing these pulsars, and since there is tremendous astrophysical interest in them, we would gain some support for our facility by offering opportunities for pulsar research, or conducting and publishing such research.

Our biggest technical limitation is our traditional use of "long" integration times to look for radio events. From the **Ohio Survey** of thirty years ago to the current **LOBES** and continuum surveys, we accumulate a signal (*by analog and digital means*) over about ten seconds, in order to pull the signal out from the background of noise and other events. This is far longer than the period of any known pulsar, not to mention the even faster sampling rates needed to "catch" a pulse that is milliseconds wide.

However, pulsar researchers have a similar problem in finding pulsar pulses in the noise. Their solution is to do a different hind of "integration". They collect samples at millisecond rates and combine them digitally over various "periods" of time in an attempt to find the right periods to match a potential pulsar. This "multiple averaging" is like using a strobe light to "freeze" the apparent motion of a rotating or moving object. Other methods involve Fourier and related techniques to look for peak responses in a "frequency domain" analysis of received signals, again sampled at millisecond rates. Dr. Phil Schumacher has recently tried to model pulsar signal behavior under these conditions, using data and discussion I've provided. These methods are similar to methods in discussion for **Serendip** operation and for **Argus** designs, which again suggests some "common ground" for research and discussion between astrophysists and **SETI** researchers.

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Radio Observatory internal Internet discussions

AUTHOR'S PROFILE:
Herb Johnson is an engineer (*BSEE OSU 1976*) who rejoined the **Observatory** in 1994. He has visited from his home near Princeton NJ to work on the punchcard archives, producing a list of cardboxes and their contents. He gave a talk on our **SETI** program at a **Space Development** conference in Cleveland last fall which he will extend into a self-contained slide presentation of **Observatory** history for our general use. He is also an amateur astronomer and works on designing electronic cameras for astronomy. He can be reached via **Internet** as *hjohnson@pluto.njcc.com*.

NASA PLANS ROBOTIC LUNAR MISSION

WASHINGTON (*AP*) — **NASA** plans to launch a low-budget robot craft to orbit the moon and fill in gaps of knowledge about the Earth's nearest celestial neighbor.

The space agency announced Tuesday that the mission, to be called **Lunar Prospector**, will cost about $59 million and is scheduled for launch in June 1997.

Instruments aboard the unmanned craft will map the chemical composition of the lunar surface, measure the magnetic and gravity fields of the moon and search for evidence of frozen water in the chilled shadows of craters near the lunar poles.

The moon craft will be just over four feet in diameter, far smaller than the craft that carried six crews to the lunar surface during the *Apollo* program.

Operating from orbit, the Lunar Prospector will carry three spectrometers. These instruments will capture emissions radiating from the moon's surface. Measuring these emissions enables scientists to determine the surface composition of the lunar soil.

National Aeronautics and Space Administration leader *Daniel S. Goldin* said the moon mission is part of the space agency's new effort to explore the universe with relatively cheap, quickly built spacecraft. The effort, called the **Discovery Program**, has prompted 28 space mission proposals.

"I am absolutely thrilled with the potential of these missions and with the universally high quality of the 28 proposals submitted to us," said the **NASA** administrator.

The Discovery Program focuses on use of small planetary probes that have specific scientific goals and can be built within 36 months for less than $150 million. Costs of the launch rocket are not included in the Discovery Program limitation.

NASA announced that three proposed Discovery missions will undergo detailed study over the next six to nine months and that one of the proposals will be selected this fall for development.

The candidate missions are:
Stardust: Sending a small craft through the dust trail of the comet P/Wild 2 and returning samples of comet material to Earth.
Venus Multiprobe Mission: Dropping 16 probes on Venus to study the properties of that planet's thick atmosphere.
Suess-Urey: Collect particles streaming from the sun and return them to Earth for study.

Two low-cost missions already are being assembled. A probe to orbit the asteroid **Eros** will be launched next February. **Mars Pathfinder**, a mission to land a small craft and a toy-sized rover on Mars, will be launched in November 1996.

COORDINATOR'S CORNER
By: Phil Barnhart

Random thoughts:

The 'new' (*prospective*) landlords for the **Radio Observatory** appear to be in the golfing industry. This speaks strongly for a desire to make the ground plane a putting green and fairway. We do not know their attitude nor identity.

We do not know how 'negotiations' are progressing. Not rapidly, at any rate. Time scales are muddy. OSU is on the record with the 'old' landlord as". . intending to renew the lease." No money will be forthcoming in the bargain.

It seems both the radio and optical (*Perkins*) observatory are included in the deal along with the existing 9 hole golf course. We, who are using the radio telescope 24 hours a day 365 days a year, are very much in the dark.

A REQUEST: If you have volunteered time, effort and material to the observatory over the past year, please send a reasonable estimate of that time to me so I may include it in a 'report' for publicity (*?*) purposes.

MISSIONS TO THE MOON, SUN, VENUS AND A COMET PICKED FOR DISCOVERY

A mission to study the Moon has been selected for funding as part of **NASA's Discovery Program**, an on-going Agency effort to foster the development of frequent, low-cost solar system exploration missions. Missions to study the Sun, Venus and a comet also have been selected for further detailed study under the Discovery effort.

The mission to the *Moon*, known as **Lunar Prospector**, was judged mature enough to proceed directly to full development and construction, following final technical definition. Scheduled for launch in June 1997, the $59 million project will map the chemical composition of the lunar surface and the Moon's global magnetic and gravity fields at a level of detail greater than that achieved by previous missions. The mission also should locate any significant quantities of water ice in shadowed craters near the lunar poles, a key issue for any future human exploration.

The other three Discovery missions will undergo detailed study for the next six to nine months, leading to a fall 1995 decision to pick one for development and flight. They are:
Stardust, which would fly through the extended coma of the active comet P/Wild 2, taking images and returning a sample of its cometary dust to Earth laboratories;
The Venus Multiprobe Mission, which would drop 16 small probes into the thick Venusian atmosphere to enable study of its unusual atmospheric circulation; and
Suess-Urey, which would collect samples of solar particle matter streaming outward from the Sun and return it to Earth for laboratory study.

I am absolutely thrilled with the potential of these missions, and with the universally high quality of the 28 proposals submitted to us," said **NASA** *Administrator Daniel S. Goldin*. "The university and aerospace industry communities should be proud of their efforts, which represent a model of how to pursue scientifically first-rate space exploration using small, advanced spacecraft."

The Lunar Prospector will be built and launched on a Lockheed Launch Vehicle by Lockheed Missiles and Space Co., Sunnyvale, CA, under the direction of *Principal Investigator Dr. Alan Binder of Lockheed*. **NASA's Ames Research Center**, Mountain View, CA, will be responsible for one of the spacecraft's instruments and technical support.

The Suess-Urey team is led by *Principal Investigator Dr. Donald Burnett of the California Institute of Technology Pasadena*, CA, with Martin Marietta Astronautics of Denver, CO, as the contractor. The Venus Multiprobe Mission team is led by *Principal Investigator Dr. Richard Goody of Harvard University* in Cambridge, MA, with Hughes Space and Communications Group, El Segundo, CA, as the industry contractor. The Stardust team is led by *Principal Investigator Dr. Donald Brownlee of the University of Washington* in Seattle, with Martin Marietta as the contractor. **NASA's Jet Propulsion Laboratory**, Pasadena, CA, will provide project management for these three missions.

Discovery missions are far less expensive than any mission we have ever done in planetary exploration, yet they promise to deliver excellent science," said Dr. Wesley T. Huntress Jr., NASA Associate Administrator for Space Science. "We've turned the old way of doing business upside down."

Formally started in NASA's FY 1994 budget, the Discovery program features small planetary exploration spacecraft with focused science goals that can be built in 36 months or less, for less than $150 million (*FY92$*), not including the cost of the launch vehicle. The program grew out of discussions and workshops that **NASA** has held with the science community.

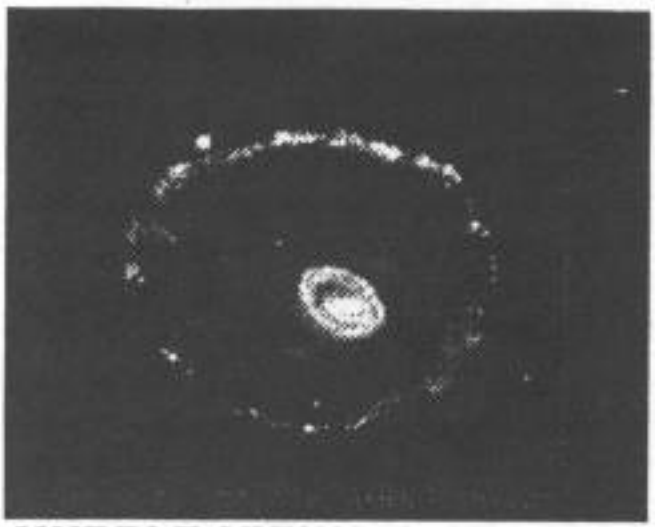
Stardust would be launched on a Med-Lite in February 1999 for a total cost to **NASA** of $208 million. The Venus Multiprobe Mission would be launched on a Delta II launch vehicle in June 1999 for a total cost to **NASA** of $202 million. Suess-Urey would be launched on a **NASA** Med-Lite launch vehicle in August 1999 for a total mission cost to **NASA** of $214 million.

Twenty-eight formal proposals for the next Discovery missions were received by **NASA** in October 1994 in response to an August 1994 Announcement of Opportunity (*see attached list*).

Two missions are already under development in the Discovery program: the Near Earth Asteroid Rendezvous mission, scheduled for launch in February 1996 to orbit around the asteroid Eros beginning in January 1999; and Mars Pathfinder, a small surface lander and rover that will be launched to Mars in November 1996 and land in July 1997.

NASA officials hope to release Announcements of Opportunity for new Discovery investigations on the average of every 18 months. The actual release dates depend on future approved **NASA** budgets and the size of previously selected missions.

HUBBLE VIEWS A STARRY RING WORLD BORN IN A HEAD-ON COLLISION



HUBBLE VIEWS A STARRY RING WORLD BORN IN A HEAD-ON COLLISION

A rare and spectacular head-on collision between two galaxies appears in this **NASA Hubble Space Telescope** true-color image of the **Cartwheel Galaxy**, located 500 million light-years away in the constellation Sculptor. The new details of star birth resolved by Hubble provide an opportunity to study how extremely massive stars are born in large fragmented gas clouds. The striking ring-like feature is a direct result of a smaller intruder galaxy that careened through the core of the host galaxy.

Like a rock tossed into a lake, the collision sent a ripple of energy into space, plowing gas and dust in front of it. Expanding at 200,000 miles per hour, this cosmic tsunami leaves in its wake a firestorm of new star creation.

Hubble resolves bright blue knots that are gigantic clusters of newborn stars and immense loops and bubbles blown into space by exploding stars (*supernovae*) going off like a string of firecrackers.

The **Cartwheel Galaxy** presumably was a normal spiral galaxy like our Milky Way before the collision. This spiral structure is beginning to re-emerge, as seen in the faint arms or spokes between the outer ring and bulls-eye shaped nucleus. The ring contains at least several billion new stars that would not normally have been created in such a short time span and is so large (*150,000 light-years across*) our entire Milky Way Galaxy would fit inside.

Hubble's new view does not solve the mystery as to which of the two small galaxies might have been the intruder. The blue galaxy is disrupted and has new star formation which strongly suggests it is the interloper. However, the smoother-looking companion has no gas, which is consistent with the idea that gas was stripped out of it during passage through the Cartwheel Galaxy.

Hubble's detailed view shows the knot-like structure of the ring, produced by large clusters of new star formation. Hubble also resolves the effects of thousands of

supernovae on the ring structure. One flurry of explosions blew a hole in the ring and formed a giant bubble ofhot gas. Secondary star formation on the edge of this bubble appears as an arc extending beyond the ring.

Hubble resolves remarkable new detail in the galaxy's core. The reddish color of this region indicates that it contains a tremendous amount of dust and embedded star formation. Bright pinpoints of light are gigantic young star clusters.

The picture was taken with the **Wide Field Planetary Camera-2** on October 16, 1994. It is a combination of two images, taken in blue and near-infrared light.

Credit. Kirk Borne (ST Scl), and NASA

GASPRA REGIONS NAMED AFTER JPL GALILEO SCIENTISTS

Two former **JPL** scientists on the **Galileo Project** have been honored by having regions on the asteroid Gaspra named after them. **Yeates Regio** honors the late **Dr. Clayne Yeates**, who was Galileo science manager from Project inception and science and mission design manager at his death in 1991. **Dunne Regio** was named in honor of the late **Dr. James Dunne**, who served Galileo for over a decade and followed Yeates as science and mission design manager until his death in late 1992.

Both contributed greatly to Galileo's successful encounter with Gaspra in October 1991 and to the Project in general: A third region was named for **G. Neujmin**, the Ukrainian astronomer who discovered the asteroid in 1916. The **International Astronomical Union** (*IAU*) recently approved these names, as well as new designations for various craters on Gaspra, named after resorts and spas around the world. This follows from the fact that Gaspra was named for a resort on the Crimean Peninsula. Recently named craters include Calistoga for a resort in California, Baden-Baden, and Yalta, after a Ukrainian resort.

SCIENTISTS SOLVE MATTER PUZZLE

BATAVIA, Ill. (*AP*) — In what some scientists say could be the last hurrah for groundbreaking U.S. research into the fundamental nature of matter, physicists announced Thursday they have isolated the long-theorized subatomic particle known as the "top quark."

The breakthrough came from two teams of physicists — each about 450 members strong — working in good-natured competition at the **Fermi National Laboratory**'s particle accelerator to isolate the last of six tiny building blocks of matter.

There was this one piece of the puzzle missing," said **Stanford University** physicist *Michael Peskin*. "You know what shape it is and you know where it goes, but you're not satisfied until you can put it in the right place."

Physicists across the nation eagerly watched the announcement broadcast live from Fermi, about 30 miles west of Chicago, where scientists could barely contain their enthusiasm.

We're delighted that the top quark has waited for discovery until we were mature enough to make it," said *Paul Grannis*.

[Back to List of Issues in Volume 11] | **[Back to List of Volumes]** | **[HOME]**

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