Star Stuff

FERA
Ford Employees Recreation Association

THE FORD AMATEUR ASTRONOMY CLUB NEWSLETTER

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SCIENTISTS DISCOVER JET STREAMS INSIDE THE SUN

Scientists Discover Massive Jet Streams Flowing Inside The Sun
From NASANews@hq.nasa.gov (Release: 97-184)

Scientists using the joint European Space Agency (ESA)/NASA Solar and Heliospheric Observatory (SOHO) spacecraft have discovered "jet streams" or "rivers" of hot, electrically charged gas called plasma flowing beneath the surface of the Sun. They also found features similar to trade winds that transport gas beneath the Sun's fiery surface.

These new findings will help them understand the famous sunspot cycle and associated increases in solar activity that can affect the Earth with power and communications disruptions. The observations are the latest made by the Solar Oscillations Investigation (SOI) group at Stanford University, Palo Alto, CA, and they build on discoveries by the SOHO science team over the past year.

"We have detected motion similar to the weather patterns in the Earth's atmosphere," said Dr. Jesper Schou of Stanford. "Moreover, in what is a completely new discovery, we have found a jet-like flow near the poles. This flow is totally inside the Sun. It is completely unexpected, and cannot be seen at the surface."

"These polar streams are on a small scale, compared to the whole Sun, but they are still immense compared to atmospheric jet streams on the Earth," added Dr. Philip Scherrer, the SOI principal investigator at Stanford. "Ringing the Sun at about 75 degrees latitude, they consist of flattened oval regions about 17,000 miles across where material moves about 10 percent (about 80 mph) faster than its surroundings. Although these are the smallest structures yet observed inside the Sun, each is still large enough to engulf two Earths."

Additionally, there are features similar to the Earth's trade winds on the surface of the Sun. The Sun rotates much faster at the equator than at the poles. However, Stanford researchers Schou and Dr. Alexander G. Kosovichev have found that there are belts in the northern and southern hemispheres where currents flow at different speeds relative to each other. Six of these gaseous bands move slightly faster than the material surrounding them. The solar belts are more than 40 thousand miles across and they contain "winds" that move about ten miles per hour relative to their surroundings.

The first evidence of these belts was found more than a decade ago by Dr. Robert Howard of the Mount Wilson Observatory. The Stanford researchers have now shown that, rather than being superficial surface motion, the belts extend down to a depth of at least 12,000 miles below the Sun's surface.

"In one way, the Sun's zonal belts behave more like the colorful banding found on Jupiter than the region of trade winds on the Earth," said Stanford's Dr. Craig DeForest. "Somewhat like stripes on a barber pole, they start in the mid-latitudes and gradually move toward the equator during the eleven-year solar cycle. They also appear to have a relationship to sunspot formation as sunspots tend to form at the edges of these zones.

"We speculate that the differences in speed of the plasma at the edge of these bands may be connected with the generation of the solar magnetic cycle which, in turn, generates periodic increases in solar activity, but we'll need more observations to see if this is correct," said DeForest.

Finally, the solar physicists have determined that the entire outer layer of the Sun, to a depth of at least 15,000 miles, is slowly but steadily flowing from the equator to the poles. The polar flow rate is relatively slow, about 50 miles per hour, compared to its rotation speed, about 4,000 miles per hour; however, this is fast enough to transport an object from the equator to the pole in a bit more than a year.

"Oddly enough, the polar flow moves in the opposite direction from that of the sunspots and the zonal belts, which are moving from higher to lower latitudes," said DeForest.

Evidence for polar flow previously had been observed at the Sun's surface, but scientists did not know how deep the motion extended. With a volume equal to about 4 percent of the total Sun, this feature probably has an important impact on the Sun's activity, argue Stanford researchers Scherrer, with Dr. Thomas L. Duvall Jr., Dr. Richard S. Bogart, and graduate student Peter M. Giles.

> *"It is intriguing to speculate that these streams may affect solar weather like the terrestrial jetstream impacts weather patterns on Earth"*
>
> Douglas Gough

For the last year, the SOHO spacecraft has been aiming its battery of 12 scientific instruments at the Sun from a position 930,000 miles sunward from the Earth. The Stanford research team has been viewing the Sun's surface with one of these instruments called a Michelson Doppler Imager that can measure the vertical motion of the Sun's surface at one million different points once per minute. The measurements show the effects of sound waves that permeate the interior. The researchers then apply techniques similar to Earth-based seismology and computer-aided tomography to infer and map the flow patterns and temperature beneath the Sun's roiling surface.

"These techniques allow us to peer inside the Sun using sound waves, much like a doctor can look inside a pregnant woman with a sonogram," said Dr. Schou.

Currently, the Stanford scientists have both identified new structures in the interior of the Sun and clarified the form of previously discovered ones. Understanding their relationship to solar activity will require more observations and time for analysis.

"At this point, we do not know whether the plasma streams snake around like the jet stream on Earth, or whether it is a less dynamic feature," said Dr. Douglas Gough, of Cambridge University, UK. "It is intriguing to speculate that these streams may affect solar weather like the terrestrial jetstream impacts weather patterns on Earth, but this is completely unclear right now. The same speculation may apply to the other flows we've observed, or they may act in concert. It will be especially helpful to make observations as the Sun enters its next active cycle, expected to peak around the year 2001." ☆

NEW MARS INFORMATION

Mars analysis — geologically peaceful for 4.53 billion years
From The University of Michigan, News and Information Services

ANN ARBOR — While the NASA Pathfinder rover, Sojourner, sniffs rocks on the surface of Mars, University of Michigan geologists have completed their own analysis of Mars rocks here on Earth. Results of a U-M analysis of tungsten isotopes in Martian meteorites, published in this week's issue of Nature, show that Sojourner is sitting on a planet whose internal structure has remained essentially unchanged since the earliest history of our solar system.

"The tungsten isotopic composition of the eight meteorites analyzed in our study indicates that large-scale convection, which drives plate tectonic motion and mixes the Earth's mantle, appears to have been unimportant during most of the history of Mars," said Alexander N. Halliday, a U-M professor of geological sciences. "The data also suggest that Mars formed fast and differentiated early in the solar system's history — about 20 to 40 million years faster than the Earth's own differentiation into a dense metal core, partially molten silicate rock mantle and thin surface crust."

Scientists believe the planets in our solar system began forming about 4.57 billion years ago from a huge cloud of interstellar gas, dust and debris leftover from the birth of the sun. The Earth and other rocky planets in the inner solar system built up gradually over millions of years as their gravitational pull attracted larger and larger chunks of material from the cloud. "Mars appears to have formed over a 10-million-year period very early in the solar system's existence," said Der-Chuen Lee, a U-M post-doctoral research fellow in geological sciences and co-author of the study. "During this formation period, energy released from the incoming rock and debris and decay of short-lived radioactive nuclides would have quickly built up inside the growing planet. This interior heat may have produced a shallow magma ocean near the Martian surface."

Metallic liquids in this magma ocean would have settled to the planet's center to form the core, while lighter silicates floated to the top, according to Lee. The process was essentially complete sometime between 10 and 30 million years after the solar system formed. "Since then, geologic activity on Mars has been sluggish, episodic and localized compared to activity on Earth. Without the constant churning, melting and mixing of mantle and surface crust produced by active plate tectonics, some features of the chemical and isotopic composition of the Martian interior have been preserved since the core formed more than 4.53 billion years ago," Halliday said.

Segregation of a metallic core on Earth was not completed for another 20 to 30 million years, according to Halliday. In previous tungsten isotopic studies, Lee and Halliday found evidence indicating that the Earth's core was not formed until at least 50 million years after the solar system began. "It is likely that this protracted development on Earth included a collision with a massive object — triggering wholesale melting and mixing of material in the growing planet. Our current study, however, produced no evidence for such a late collision on Mars," Halliday said.

Halliday and Lee used a new technique called multiple-collector, inductively-coupled plasma mass spectrometry to measure relative amounts of tungsten isotopes in Martian meteorites and acondrites — silicate-rich debris from asteroids formed soon after the solar system developed. "Hafnium-182 is an extinct radioactive isotope, which was relatively abundant in the early solar system. By comparing relative amounts of hafnium and tungsten with the relative enrichment of the daughter isotope tungsten-182 in these meteorites, we can calculate how quickly hafnium-to-tungsten ratios changed in early solar system objects," Halliday said.

"Hafnium tends to be incorporated into silicate minerals in rocks, while tungsten has an affinity for iron. When dense iron-rich melts separate from silicate melts, tungsten sinks into a planet's metallic core, while hafnium concentrates in the mantle. If you remove part of the tungsten early, the effects of the entire subsequent decay process are altered. We can tell when this occurred by measuring the abundance of tungsten-182. With the new mass spectrometry technique of multiple collector ICPMS, we can detect differences in isotopic ratios in as little as a few billionths of a gram of tungsten."

The research was funded by the National Science Foundation, the U.S. Department of Energy, NASA and the University of Michigan. Meteorites analyzed in the study were from the collections of NASA, the Smithsonian Institution in Washington, D.C., Museum National d'Histoire Naturelle in Paris, and the Field Museum in Chicago.

STAR STUFF
Monthly Publication of the Ford Amateur Astronomy Club

Star Stuff Newsletter
P.O. Box 7527
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1997 CLUB OFFICERS

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GENERAL MEETINGS

The Ford Amateur Astronomy Club holds regular general meetings open to the public on the fourth Thursday of the month at 5:00 PM. Meetings are held in conference room 100 in the Ford Worldwide Web & Internet Applications (WWW&IA) building, at 555 Republic Drive in the Fairlane Business Park in Dearborn.

OBSERVING SITE

The Ford Amateur Astronomy Club has an established observing site, by permit, at the Spring Mill Pond area of the Island Lake Recreational Area in Brighton, Michigan located near the intersections of I-96 and US-23. Members are responsible for opening and closing the gate after the parks 10:00pm closing time. The combination for the lock should be available on our hotline number. Always close the gate behind you after 10:00pm whether entering or leaving the park.

OBSERVING HOTLINE NUMBER - (313) 39-05456

On Friday and Saturday nights, or nights before holidays, you can call the hotline number up to 2 hours before sunset to find out if we will be observing that night. Assume that any clear Friday or Saturday night is a candidate observing night unless something else is going on or none of the club officers are able to make it.

WWW PAGE

Computers inside the Ford network or on the Internet can access the F.A.A.C. web page at one of the following addresses:

Ford Intranet:	http://pt0106.pto.ford.com/faac/
Internet:	http://kode.net/~dougbock/faac/

MEMBERSHIP AND DUES

Membership to the Ford Amateur Astronomy Club is open to both Ford and Non-Ford Motor Company employees. The general public is also welcome to join. The dues structure is as follows:

Annual Individual/Family	$20.00
Lifetime Membership	$100.00

Membership benefits include a subscription to the Star Stuff newsletter, discounts on subscriptions to Astronomy and/or Sky & Telescope magazine(s), after hour use of the observing site at Island Lake, and discounts at selected area astronomical equipment retailers.

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NEWSLETTER SUBSCRIPTION

A yearly subscription at a rate of $12.00 is available to those who are not members of the Ford Amateur Astronomy Club. Subscriptions are free to other astronomy clubs wishing to participate in a newsletter exchange.

SEPTEMBER 1997

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25 FAAC Meeting	26	27
28	29	30				

Sep 01 **New Moon (7:53 pm)**
Sep 04 Asteroid 1 Ceres at Opposition (7.7 Magnitude)
Sep 06 Asteroid 258 Tyche at Opposition (10.9 Magnitude)
Sep 09 **First Quarter Moon (9:32 pm)**
Sep 09 Asteroid 1996 FG3 Near-Earth Flyby (0.356 AU)
Sep 10 Asteroid 130 Elektra at Opposition (10.5 Magnitude)
Sep 10 Asteroid 4033 Yatsugatake Closest Approach to Earth (1.389 AU)
Sep 10 Comet Arend-Rigaux Closest Approach to Earth (2.218 AU)
Sep 11 Comet Grigg-Skjellerup Closest Approach to Earth (1.761 AU)
Sep 15 Asteroid 70 Panopaea at Opposition (10.8 Magnitude)
Sep 16 **Full Moon (2:52 pm)**
Sep 16 Closest Full Moon of 1997 (356,966 km)
Sep 16 Comet 1997 G1 (Montani) Perihelion (4.300 AU)
Sep 16 Mercury at Greatest Western Elongation (18 Degrees)
Sep 16 Asteroid 40 Harmonia at Opposition (9.4 Magnitude)
Sep 16 Asteroid 5349 Paulharris Closest Approach to Earth (1.625 AU)
Sep 17 Asteroid 52 Europa at Opposition (10.9 Magnitude)
Sep 18 Moon Occults Saturn
Sep 19 Asteroid 1386 Storeria Closest Approach to Earth (0.870 AU)
Sep 22 Autumnal Equinox (23:56 UT)
Sep 23 **Last Quarter Moon (9:37 am)**
Sep 25 Asteroid 3619 Nash Closest Approach to Earth (0.853 AU)
Sep 25 Asteroid 2693 Yan'an Closest Approach to Earth (0.944 AU)
Sep 27 Asteroid 2100 Ra-Shalom Near-Earth Flyby (0.1705 AU)
Sep 27 Asteroid 8 Flora at Opposition (8.1 Magnitude)
Sep 29 Comet Wolf-Harrington Perihelion (1.582 AU) ☆

MEETING ANNOUNCEMENT

The Ford Amateur Astronomy Club (FAAC) holds regular general meetings on the fourth Thursday of each month, except November and December. Our next meeting will be **Thursday, September 25, at 5:00 pm.**

The FAAC meets in conference room 100 in the Ford WorldWide Web & Internet Applications (WWW&IA) building, at 555 Republic Drive in the Fairlane Business Park in Dearborn. The find the building take the Southfield Freeway to Rotunda Drive. Go east on Rotunda and take the first right into the Fairlane Business Park (there is a sign). The WWW&IA building is the first building on the left. Park on the south or east side of the building and come to the south door (there is a big "425" over the door). The WWW&IA building is secured with a card entry system. If no one is at the door to let you in, then dial 18388 on the lobby phone and we will send someone. When you enter the building, turn left and follow along the windows to the conference room. ☆

8/28/97 MEETING MINUTES

From Harry Kindt, Sec'y FAAC

The meeting was called to order by our president Bob MacFarland at 5:00 P.M. New members were introduced and welcomed to the club. There were 25 members and guests present.

Bob reviewed the FAAC calendar for the remainder of the year. In addition to our own 5th annual star party on the 6th of September, Bob mentioned two other events we should keep in mind. The Autumnal Equinox Star Party at Doug Bock's Northern Cross Observatory on September 27th, and Doug's NCO Wilderness Campout/Star Party at his Boon, Michigan property on October 3-5, 1997. Bob also reported on the availability of the new T-shirts commemorating our 5th Annual Star Party.

The treasurers report was read and accepted. As part of our club's commitment to the FERA organization, we are again, this year, involved in the sale of tickets to the Renaissance Festival . If you wish to take part in the sale of these tickets, please contact Chuck Boren.

Don Klaser reported on the final arrangements for our 5th Annual Star Party scheduled for September 6, 1997. Everything is in order and everyone is prepared to do their part in making this another "stellar" event. The Nature Co. and Riders Hobby are sharing the cost of a 32' x 40' foot tent for their displays and for other scheduled events. Don also reported on the possibility of having another inter-club star party for Kensington Park in 1998. More details on this as they become available. Also in the planning stage, our 6th Annual Star party tentatively scheduled for the third week in September, 1998.

George Korody reported on the progress of the FAAC Scholarship Fund. Plans call for senior high school students in the natural science curriculum to submit an essay on a Astronomy related topic. A committee will be formed to judge the essay on content, style, and general knowledge of the subject. Prizes will be awarded based on the consensus reached by the judges.

Two new items of business were brought before the membership by Greg Burnett. The first item is the search for a new meeting site. Ford employees are being asked to contact their building managers too help in locating a room, in their building, in which to hold future meetings. The second item mentioned by Greg is locating a "state of the art" copying machine for the production of our newsletter. In addition we need someone to create mailing labels for the newsletter using the existing Excel database of our membership. If you would like to assist in any of these areas, please contact any of the members of the executive board.

Over our usual pizza and pop, those present had the opportunity to introduce themselves and to briefly describe some of their viewing experiences since our last meeting.

There was no featured speaker for the evening, however, George Korody brought in a video tape of a Discovery Channel program entitled Ultra-Science Cosmic Collisions. A half-hour show describing the possibility and the odds of the Earth being struck by an asteroid, comet or meteor. The program also provided us with some ideas on how to destroy, or at least divert such an object, given enough warning. The meeting was adjourned at 6:45 P.M. ☆

SEPTEMBER SPACE HISTORY

The following September events come from the 08/09/97 edition of "Space Calendar." This calendar is compiled and maintained by Ron Baalke (baalke@kelvin.jpl.nasa.gov).

Sep 05 20th Anniversary (1977), Voyager 1 Launch
Sep 08 30th Anniversary (1967), Surveyor 5 Launch (Moon Lander)
Sep 09 105th Anniversary (1892), Edward Barnard's Discovery of Jupiter Moon Amalthea
Sep 12 5th Anniversary (1992), STS-47 Launch (Endeavour), 1st Japanese Spacelab
Sep 25 5th Anniversary (1992), Mars Observer Launch
Sep 29 20th Anniversary (1977), ☆

SEPTEMBER 1997 SPACE EVENTS

The following September 1997 events come from the 08/09/97 edition of "Space Calendar." This calendar is compiled and maintained by Ron Baalke (baalke@kelvin.jpl.nasa.gov). Note that launch dates are subject to change.

Sep 10 NEAR, Thruster Calibration (CAL-1)
Sep 12 Mars Global Surveyor, Mars Orbit Insertion
Sep 13 Galileo, Orbital Trim Maneuver #32 (OTM-32)
Sep 15 GFO-1 Taurus Launch
Sep 17 Galileo, 3rd Callisto Flyby (Orbit 10)
Sep 18 STS-86 Launch, Atlantis, 7th Shuttle-Mir Mission, Logitics Module
Sep 18 Intelsat 803 Ariane 4 Launch
Sep 20 Galileo, Orbital Trim Maneuver #33 (OTM-33)
Sep 20 Progress M-38 Launch (Russia)
Sep 21 Mars Global Surveyor, Mars Aerobraking Begins
Sep 25 Iridium-4 Launch ☆

INFRARED SPACE OBSERVATORY

Infrared Space Observatory Probes Oldest Galaxies
From Royal Astronomical Society Press Notices (Ref: PN 97/33)

A team of astronomers led by Professor Michael Rowan-Robinson from Imperial College, London, has used the European Space Agency's Infrared Space Observatory (ISO) to obtain the longest exposure ever made of the 6.7-micron-wavelength infrared radiation from a single patch of sky. The images reveal remote galaxies giving out 10 to 100 times more infrared radiation than visible light. These powerful infrared signals show that new stars are being created within these galaxies at a phenomenal rate. The total rate of star formation in the universe 7 billion years ago implied by these results is considerably higher than has been estimated previously from studies in visible light. Such a result confirms the suspicion that there was much more star formation activity then than now. It seems that ISO has captured young galaxies at the peak of their star-forming ability.

A total of 13 hours of observations have been added together for this exposure. The very latest results from the observations were presented by Dr Seb Oliver, of Imperial College, at the 23rd General Assembly of the International Astronomical Union (IAU) in Kyoto, Japan, on 25 August. The new images show galaxies in their early stages of development when star formation was much more rapid than it is today. Their radiation has taken so long to travel to us, we see them as they were 7 billion years ago. Many of the newly forming stars are very massive, but are hidden in dense shrouds of dust. The light from the stars heats the dust and the galaxies appear much brighter in infrared telescopes than they do in optical telescopes, such as the Hubble Space Telescope. "Some of these galaxies are 10 to 100 times more luminous in the infrared than the optical," said Professor Rowan-Robinson. "On average perhaps 80% of the star formation is hidden from normal view and is only visible in the infrared."

The Imperial College team members concentrated their observations on the area of sky known as the Hubble Deep Field because the Hubble Space Telescope looked at it for about 10 days in December 1995. The patch of sky is about the same as the apparent size of the planet Venus. One of their objectives was to use ISO's unique sensitivity in the infrared to discover more about the distant galaxies in the Hubble Deep Field, which we now see as they were when they were so young that they were still in the process of being assembled. To achieve this, the team has been carrying out a survey of this tiny segment of sky at the infrared wavelengths to which ISO is most sensitive — 6.7 and 15 microns.

Following a preliminary report at a meeting of the Royal Astronomical Society on 8 November 1996, the team repeated its observations of the Hubble Deep Field at 6.7 microns in order to obtain maps of even fainter objects and study more galaxies at this interesting wavelength. The new observations were made in July 1997 in the last few days that the field was visible to ISO. After collecting ISO observations equivalent to a total exposure lasting 13 hours, the Imperial College team and their collaborators have found many additional galaxies. There are far more galaxies than they expected taking into account the normal amount of infrared radiation emitted by ordinary stars and galaxies like our own Milky Way. The extra infrared emission is a sign of dramatic bursts of star formation taking place deep inside clouds of gas and dust. These findings indicate that galaxies emitting strongly in the infrared were either much more common or more luminous in the past than they are now.

Matching the galaxies seen by ISO with the galaxies detected in visible light (for which distances are either known or have been estimated on the basis of their colours) allows the distance to each galaxy to be determined. This, in turn, makes it possible to estimate their luminosities and the rate at which they are forming stars. A particular surprise was the prodigious rate at which stars were being born in these galaxies — from 8 to 1000 solar masses per year — compared with about 1 solar mass per year in our Milky Way galaxy today. Many of the galaxies at redshifts between 0.5 and 1 (at the limit of ISO's sensitivity) are undergoing dramatic episodes of star formation known as 'starbursts'. The total rate of star formation in the universe at around a redshift of 1 implied by these results is considerably higher than has been estimated previously from studies at optical wavelengths. It confirms suspicions that there was much more star formation activity at these epochs than at the present time, but that much of that activity is hidden from optical telescopes by large quantities of dust. ☆

RADIO ASTRONOMY

From Dick Lawrence

I sometimes think about radio astronomy and wonder if I might be interested or able to build a radio telescope. It seems to be very interesting to those involved in it, but if you pick up a book or magazine about the subject it is almost impossible to make any sense out of it. I admit I have tried several times to get started but I did not know where to begin. I even joined an organization called SARA (Society of Amateur Radio Astronomers). They publish a good newsletter, but even this did not answer all of my questions. However, there is light at the end of the tunnel. This year the club held their yearly membership meeting at Greenbank, WV, and I attended. There are club members all over the world including the US, Europe, and South America, and about 50 members made it to the meeting at one of the governments most important radio astronomy sites.

The members I met were a very committed group who delight in helping a new person understand and get started in radio astronomy. In addition, the government people employed there are more than willing to help by giving tours of the various radio telescopes as well as training sessions given by professional astronomers. The club members spent a lot of time giving forums on all sorts of information related to building and operating your own radio telescope. (Club members were allowed to use a 40-foot dish antenna using their own radio telescope equipment. This resulted in a lot of excitement when the equipment performed as expected.) I cannot stress what an enjoyable time it is to attend this meeting. It was so informative that I now am beginning to feel comfortable about the subject. If you think you might be interested write SARA at 247 N. linden Street, Massapequ, NY 11758. You will receive a nice information packet about the club and radio astronomy in general. I especially liked the list of related reading material. Membership dues are $24. ☆

Relive the Days of Knights!

The Ford Amateur Astronomy Club is selling Michigan Renaissance Festival tickets in association with FERA. The Renaissance Festival is a very popular event and there shouldn't be any trouble in selling tickets. As a club within the Ford Employees Recreation Association, we are required to participate in one FERA sales event each year. It is because of FERA that we can use Ford facilities, etc. Let's show our support by doing our best to sell these tickets!! Contact Chuck Boren (CBOREN, 313-24-83446) if you would like to sell or purchase tickets.

ADULTS $10.50
($12.95 at the gate)

CHILDREN $4.50
($5.95 at the gate)

Weekends through September 28, 1997
10:00 am to 7:00 pm -- Rain or Shine

Michigan Renaissance Festival

ISO AND OUR COSMIC ANCESTRY

From European Space Agency (ESA), Press Information Note Nr 25-97

The ESA's Infrared Space Observatory, ISO, is unmatched in its ability to explore and analyse many of the universal processes that made our existence possible. We are children of the stars. Every atom in our bodies was created in cosmic space and delivered to the Sun's vicinity in time for the Earth's formation, during a ceaseless cycle of birth, death and rebirth among the stars.

The most creative places in the sky are cool and dusty, and opaque even to the Hubble Space Telescope. Infrared rays penetrating the dust reveal to ISO hidden objects, and the atoms and molecules of cosmic chemistry. "ISO is reading Nature's recipe book," says Roger Bonnet, ESA's director of science. "As the world's only telescope capable of observing the Universe over a wide range of infrared wavelengths, ISO plays an indispensable part in astronomical discoveries that help to explain how we came to exist." This Information Note describes several stages in our cosmic ancestry, revealed when ISO examines their counterparts still observable today.

The evolving galaxies

In the beginning was hydrogen, mixed with helium and minute traces of other light atoms. These were the atomic products of the Big Bang, the hypothetical cataclysm that created the Universe more than 10 billion years ago. The primeval gas was very dull. Nature could not make dust from it, never mind a living creature. But gravity gathered the hydrogen and helium into stars, and by nuclear reactions the stars glowed. As the first stars aged, the reactions made novel chemical elements like carbon, oxygen and silicon. Expelled into the stars' surroundings, these materials reacted with one another and with hydrogen to make the icy, tarry and stony grains of cosmic dust. The vast assemblies of stars called galaxies became crucibles where Nature could use physics and chemistry to make new materials and new stars. Rays from the most distant galaxies have taken so many billions of years to reach us that we see them as they were when they were young. The farthest galaxy observed so far by ISO is a quasar called BR 1202-0225, dating from a time when the Universe was less than one-tenth of its present age. Already it is dusty.

ISO has also observed many galaxies at about half the age of the Universe, by staring long and hard through a window in the dust of our own Milky Way Galaxy, called the Lockman Hole. In those that glow most brightly in the infrared, astronomers suspect that frantic star-making is in progress, in episodes called starbursts. In nearer galaxies, ISO's astronomers can relate strong infrared emissions to collisions and to violent eruptions in the galactic cores, which have punctuated the evolution of the galaxies. "Having ISO in space brings special opportunities for the study of the history of the galaxies," says the Japanese astronomer Yoshiaki Taniguchi of Tohoku University. "By detecting infrared wavelengths that are hard to observe from the Earth, ISO picks out very clearly the galaxies that are evolving most rapidly, in periods of intensive starmaking. Also some sources may be infrared galaxies powered by active galactic nuclei."

The Milky Way Galaxy where we live acquired its name from the starry disk that we see edge-on as a ribbon of light. It has had a quiet history compared with some other galaxies, but the tranquillity is only relative. Violent events have made and destroyed stars throughout the Galaxy's life. The wreckage is strewn all around us. When ISO surveys cross-sections of the Milky Way it detects old cool stars and young dusty stars glowing strongly in the infrared. But the main features of the images are thin dust clouds sprawling across the sky, made by the scattered debris of defunct stars. Here and there, thicker and more luminous dust clouds are the scenes of new star formation. It was in just such a dusty environment that the Sun and the Earth were born.

Death and rebirth among the stars

The Sun is a middle-aged star. It was formed about 4.5 billion years ago, when the Universe was not much more than half its present age. Now the Sun is about half-way through its expected life-span. In the Sun, the Earth and our own bodies, all atoms heavier than than the primeval hydrogen and helium were made in stars of the Milky Way that expired before the Sun came into existence. Grains of different origins, found in meteorites and distinguished by atomic fingerprinting, confirm that many individual stellar ancestors contributed to the Solar System's stock of elements. The ashes of the ancestral stars are too dispersed to be identifiable in the Galaxy today. Astronomers can nevertheless find their analogues among more recent stars. ISO gives them special access to the stages between stellar death and rebirth.

An old star expiring scatters chemically enriched material into the interstellar medium, which concentrates again at the origin of new stars and planets. Extraordinary success in analysing the chemical composition of the gases and dust in the vicinity of old and new stars, and in comets too, has been a major contribution from ISO. As described in previous Information Notes, materials identified by their infrared signatures include carbon monoxide and water in vapour or icy form, tarry carbon-rich compounds, and minerals including olivine, which is a major constituent of the Earth's rocky mantle.

When the Sun itself grows old, it will swell and cool, and will eventually puff much its material into space. Its burnt-out core will collapse to make a white dwarf star. A star of roughly solar mass, seen in the last phase of its expiry, makes a planetary nebula — a sphere of scattered ashes around the glowing ember of the white dwarf. ISO has examined several planetary nebulae, including the Helix Nebula, the subject of a newly released picture from ISO showing remarkable detail. Massive stars not only burn up much more quickly than sun-like stars, but perish more spectacularly in supernova explosions. For a few weeks, an exploding star glows more brightly than a billion suns. Its interior collapses to make a neutron star far denser than a white dwarf, and the star blasts its outer layers into space. One reason why supernovae are important in the chemical scheme of the cosmos is that only they can make the heaviest elements, such as gold and uranium.

The remnant of a supernova remains discernible for thousands of years after the explosion. The most recent supernova observed in the Milky Way Galaxy occurred little more than 300 years ago and the resulting nebulous object is called Cassiopeia A. ISO has made the first detailed examination of Cassiopeia A by infrared rays unobservable from the Earth's surface. It gives direct evidence of dust formation. "The newly cooked elements provided by the supernova have to cool before they can create fresh supplies of interstellar dust," comments Pierre-Olivier Lagage of CEA SAp at Saclay (France) who led this study of Cassiopeia A. "With ISO's camera we can pick out emissions from various elements, and we find that clumps of hot material flung out from the star evolve directly into corresponding clumps of dust."

In contrast the Trifid Nebula is region of rebirth, where massive stars of a new generation are forming. Seen by visible light, hot young stars light up a large cloud of gas. It is criss-crossed by dark dust clouds which divide the bright nebula and give it its name. An infrared image from ISO shows a remarkable change in appearance. The dark clouds become luminous and the bright regions are dark. By its trick of penetrating the dust, ISO reveals dense regions inside the obscuring clouds, where new stars are forming.

The cosmic egg from which a star will hatch

One prize sought by ISO astronomers has been the detection of the earliest stages of star formation. Pre-stellar cores are egg objects hidden within a larger dust cloud. A cold, thick shell of dust obscures the interior, where gas collapses under gravity to make an embryonic star. By the time the dust has dispersed, and the object inside has hatched as a plainly visible star, the main event of star formation is complete. In the earliest stages, only radio waves and far-infrared rays can escape from the dust cloud, allowing us to observe the real origins of the stars.

Derek Ward-Thompson of the Royal Observatory Edinburgh (UK) and his colleagues at Cambridge University and in France, first detected the pre-stellar core L1689B, using observations at sub-millimetre radio wavelengths, in the constellation Ophiuchus. It is a very young pre-stellar core, on the brink of collapsing to form a new star. Now the team has used ISO to make the first infrared images of L1689B using the photometer ISOPHOT at long infrared wavelengths, up to its limit of 200 microns. The shell of dust is so cold, at roughly minus 260 degrees Centigrade (or 13 K), it is undetectable even at short or medium infrared wavelengths.

Astronomers can now combine ISO's results with observations of the same object and others like it, at sub-millimetre radio wavelengths, to build up a detailed picture of the earliest stages of star formation. Ward-Thompson says: "Our fellow-astronomers thought we had no chance of detecting pre-stellar cores with any instruments available today. Now that we've done it, with the radio telescopes on the ground and with ISO in space, a new chapter in the study of star formation can begin. Already our results contradict the theory that a pre-stellar core should spin rapidly. It doesn't. In addition, our observations have shown us that the manner in which a newly-forming star first collapses is different from that which was previously predicted.

(continued on page 6)

(continued from page 5)

Looking for the origin of planets

Our immediate cosmic mother was the Solar Nebula, the cloud of gas and dust that supposedly swirled around the Sun at its birth about 4.5 billion years ago. Gravity flattened the gas and dust into a disk, like a giant version of the rings of Saturn. and icy grains of dust congealed to make the Sun's family of planets, including the Earth. The comets are relics of the construction of the Solar System, and ISO has investigated their chemical composition. Yet the concept of planet-making in the dusty disk of the Solar Nebula was just a theory until the advent of infrared space astronomy.

One of the more time-intensive programmes of ISO deals with the existence of disks of dust particles around normal stars. The Sun still has a disk, visible as the Zodiacal Light seen close to horizon after sunset in spring or before sunrise in autumn. The dust is, however, too sparse to be detected, if one were looking for a similar feature in the surroundings of another star. Therefore it came as a big surprise when ISO's predecessor, the Dutch-US-UK Infrared Astronomical Satellite (1983), detected similar dust disks around a few nearby stars, notably Vega and Beta Pictoris, with much more material than the Sun's dust disk. However, the material is much colder than the zodiacal cloud and thus farther away from the stars. In our solar system this would be beyond Neptune.

The disks fascinate astronomers because they show the presence of material around stars that is left over from the time of their formation. This suggests that many stars other than the Sun may have a "solar system" of planets, asteroids and comets around them. Although there are some other ways to get more information about such "solar system" disks, it falls to ISO to take the next big steps. These are to observe many more stars at much higher sensitivity, to establish how often such disks occur, and to see for how long how they can survive the natural processes that tend to destroy them. The first results show that ISO detects weak disks in some cases. In a few others it sets upper limits to possible dust. Some disks are detected at quite long wavelengths, indicating that they extend to fairly far away from the star. Data-reduction of observations of many more stars is in progress. A preliminary conclusion is that the existence of a disk is a property of many but clearly not all stars.

Background on ISO

Advanced technology created ISO's extremely cold telescope capable of observing cool regions of the Universe. Multinational teams, with leaders in France, Germany, the Netherlands and the United Kingdom, developed the special scientific instruments. A European Ariane 44P launcher put ISO into orbit on 17 November 1995. Requests from the world's astronomers for observations with ISO have always far exceeded the available operating time, even though the spacecraft's controllers at ESA Villafranca supervise an average of 45 astronomical observations every day. ☆

OBSERVATIONS

by Greg Burnett

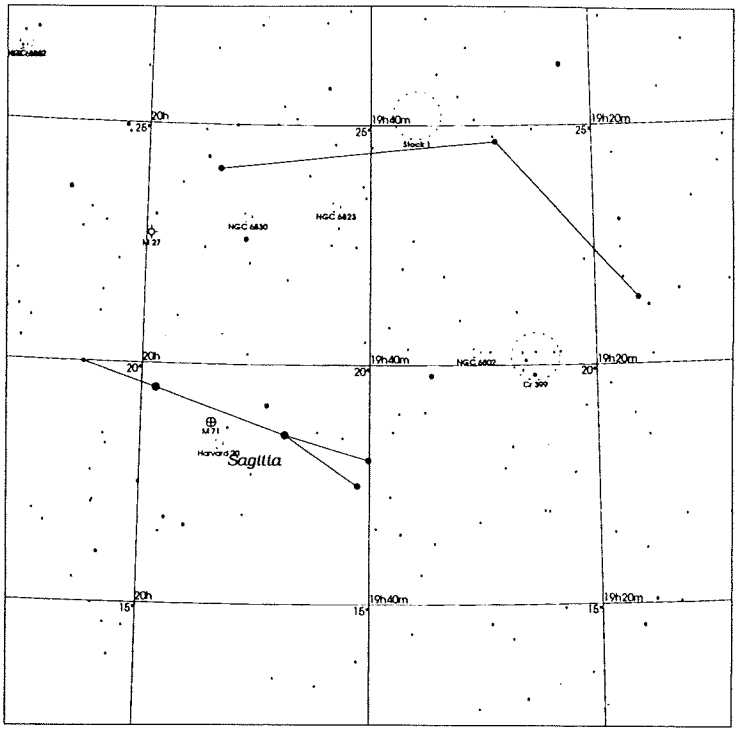
It's two o'clock in the morning. A ghostly fog bank hovers over the pond, threatening to drift up the beach in our direction. My book of charts is already soggy; the open page swollen, bigger than the rest. A mosquito bite on my knuckle reminds me I am prey. I hear one buzzing around my ear, searching out that inevitable tiny spot missed by the DEET. The night enfolds, like a damp, woolly blanket, but provides no warmth. Movements become slow-motion, voices muffled, shadowy hands groping, as if underwater. Not much can be seen beyond my LEDs, except the looming glow of the horizon, and... "What am I doing out here?" ...oh yes, the stars!

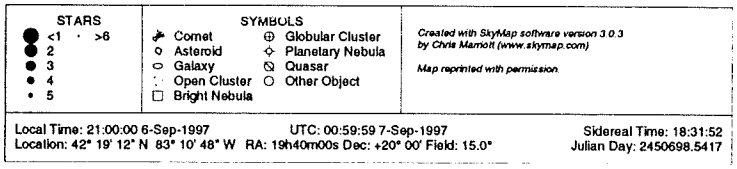
Distant campfires of ancient tribes. Stitch-holes in the fabric of the Universe, where the fires of the gods shine through. Great suns flung out across the howling abyss, their magnificence enfeebled by vastness beyond our imagining. But we go there,... tonight,... every night. We go far above the clouds, soaring beyond the rills and grabens of the Moon, through star-fog and smoke where new suns are forged, into the cores of great swarming clusters of mighty suns, even to the glowing gates of whirling galactic star-cities, where all we can dream becomes true.

That's what I'm doing out here. Going where we go on these nights, in the company of good friends, hoping for that magic moment when, cosmic forces converging before us, the Universe once again whispers some deep secret, and we are there to listen. ☆

SEPTEMBER POINTS OF INTEREST

On the night of our Island Lake Star Party (Saturday, September 6, 1997) the constellations Vulpecula, The Fox, and Sagitta, The Arrow, will be roughly overhead around 10:00 pm. While some people may be tempted to once again look at the area's most famous member, M27, The Dumbell Nebula, there are several other points of interest.





NGC 6885 - (R.A. 20h 12m, Dec. +26° 29')
Magnitude: 8.1 — Magnitude of brightest stars: 6.0
Size: 7.0' — Number of stars: 30

STOCK 1 - (R.A. 19h 36m, Dec. +25° 13')
Magnitude: 5.3 — Magnitude of brightest stars: 7.0
Size: 60' — Number of stars: 40

NGC 6823 - (R.A. 19h 43m, Dec. +23° 18')
Magnitude: 7.1 — Magnitude of brightest stars: 8.8
Size: 12' — Number of stars: 30

NGC 6830 - (R.A. 19h 51m, Dec. +23° 4')
Magnitude: 7.9 — Magnitude of brightest stars: 9.9
Size: 12' — Number of stars: 20

NGC 6802 - (R.A. 19h 31m, Dec. +20° 16')
Magnitude: 8.8 — Magnitude of brightest stars: 12.9
Size: 3.2' — Number of stars: 50

CR 399 - (R.A. 19h 25m, Dec. +20° 11')
Magnitude: 3.6 — Magnitude of brightest stars: 5.2
Size: 6.0' — Number of stars: 40
Note: also known as "The Coathanger"

NGC 6838 (M71) - (R.A. 19h 54m, Dec. +18° 47')
Magnitude: 8.3 — Magnitude of brightest stars: --
Size: 7.2' — Number of stars: --

HARVARD 20 - (R.A. 19h 53m, Dec. +18° 20')
Magnitude: 7.7 — Magnitude of brightest stars: 9.8
Size: 7.0' — Number of stars: 15 ☆

STATISTICALLY SPEAKING

Location (Dearborn, MI): 42°19'12" N, 83°10'48" W, 180 meters elevation
Local Time = Universal Time - 4 hours (Eastern Daylight Savings Time)

Abbreviations used in reports:
FM Full Moon FQ First Qtr Moon LQ Last Qtr Moon NM New Moon
MR Moon Rise MS Moon Set SR Sun Rise SS Sun Set

Calendar Report for September 1997

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1 SR: 6:58 SS: 20:06 MR: 6:35 MS: 19:57	2 SR: 6:59 SS: 20:05 MR: 7:32 MS: 20:26	3 SR: 7:00 SS: 20:03 MR: 8:29 MS: 20:54	4 SR: 7:01 SS: 20:01 MR: 9:26 MS: 21:22	5 SR: 7:02 SS: 20:00 MR: 10:23 MS: 21:52	6 SR: 7:03 SS: 19:58 MR: 11:20 MS: 22:23
7 SR: 7:04 SS: 19:56 MR: 12:18 MS: 22:58	8 SR: 7:05 SS: 19:54 MR: 13:17 MS: 23:37	9 SR: 7:06 SS: 19:53 MR: 14:15 MS: None	10 SR: 7:07 SS: 19:51 MR: 15:12 MS: 0:21	11 SR: 7:09 SS: 19:49 MR: 16:06 MS: 1:12	12 SR: 7:10 SS: 19:47 MR: 16:57 MS: 2:11	13 SR: 7:11 SS: 19:46 MR: 17:45 MS: 3:15
14 SR: 7:12 SS: 19:44 MR: 18:28 MS: 4:25	15 SR: 7:13 SS: 19:42 MR: 19:08 MS: 5:38	16 SR: 7:14 SS: 19:40 MR: 19:47 MS: 6:53	17 SR: 7:15 SS: 19:39 MR: 20:24 MS: 8:09	18 SR: 7:16 SS: 19:37 MR: 21:02 MS: 9:23	19 SR: 7:17 SS: 19:35 MR: 21:42 MS: 10:36	20 SR: 7:18 SS: 19:33 MR: 22:24 MS: 11:45
21 SR: 7:19 SS: 19:32 MR: 23:09 MS: 12:51	22 SR: 7:20 SS: 19:30 MR: 23:57 MS: 13:51	23 SR: 7:21 SS: 19:28 MR: None MS: 14:45	24 SR: 7:22 SS: 19:26 MR: 0:48 MS: 15:34	25 SR: 7:23 SS: 19:24 MR: 1:42 MS: 16:17	26 SR: 7:24 SS: 19:23 MR: 2:37 MS: 16:55	27 SR: 7:26 SS: 19:21 MR: 3:33 MS: 17:29
28 SR: 7:27 SS: 19:19 MR: 4:30 MS: 18:00	29 SR: 7:28 SS: 19:17 MR: 5:26 MS: 18:29	30 SR: 7:29 SS: 19:16 MR: 6:23 MS: 18:57		Lunar Events: Sep 01 NM: 19:53 Sep 09 FQ: 21:32 Sep 16 FM: 14:52 Sep 23 LQ: 9:37		

Planet View Info Report for September 1997

Date	Rise	Set	RA	Dec	Elongation	Ill Fr	DIST(AU)
Mercury							
9/ 9/1997	5:59	19:11	10h16m34s	8°57'43"	13°40'20"	0.147	0.74134
9/16/1997	5:42	19:01	10h29m13s	9°55'41"	17°50'17"	0.437	0.91763
9/23/1997	5:59	19:01	11h03m54s	7°43'04"	15°58'35"	0.734	1.11064
9/30/1997	6:33	19:01	11h48m18s	3°18'49"	11°01'43"	0.913	1.26472
Venus							
9/ 9/1997	10:35	21:20	13h37m13s	-10°38'52"	40°02'30"	0.727	1.10058
9/16/1997	10:51	21:10	14h07m45s	-13°55'36"	41°22'29"	0.704	1.05056
9/23/1997	11:07	21:02	14h38m50s	-16°57'59"	42°37'00"	0.679	0.99973
9/30/1997	11:22	20:54	15h10m31s	-19°42'15"	43°45'13"	0.654	0.94824
Mars							
9/ 9/1997	12:19	22:09	14h54m44s	-17°35'30"	60°03'37"	0.902	1.68633
9/16/1997	12:16	21:55	15h13m41s	-18°57'02"	57°56'52"	0.906	1.72152
9/23/1997	12:13	21:42	15h33m15s	-20°12'24"	55°53'30"	0.910	1.75538
9/30/1997	12:11	21:29	15h53m28s	-21°20'33"	53°53'07"	0.914	1.78801
Jupiter							
9/ 9/1997	18:26	4:20	21h05m17s	-17°42'32"	147°10'26"	0.997	4.17242
9/16/1997	17:57	3:49	21h03m01s	-17°52'02"	139°48'15"	0.996	4.23653
9/23/1997	17:28	3:20	21h01m18s	-17°58'57"	132°32'55"	0.995	4.31128
9/30/1997	17:00	2:51	21h00m12s	-18°03'08"	125°24'51"	0.993	4.39539
Saturn							
9/ 9/1997	21:09	9:52	1h13m13s	4°49'23"	147°32'44"	0.999	8.54558
9/16/1997	20:40	9:22	1h11m36s	4°38'16"	154°45'48"	0.999	8.48975
9/23/1997	20:12	8:52	1h09m49s	4°26'18"	162°01'27"	1.000	8.44724
9/30/1997	19:43	8:22	1h07m53s	4°13'46"	169°15'47"	1.000	8.41887
Uranus							
9/ 9/1997	18:00	3:38	20h31m03s	-19°34'43"	138°52'11"	1.000	19.06124
9/16/1997	17:32	3:10	20h30m21s	-19°37'06"	131°53'20"	1.000	19.14647
9/23/1997	17:04	2:41	20h29m46s	-19°38'58"	124°54'57"	1.000	19.24131
9/30/1997	16:36	2:13	20h29m21s	-19°40'17"	117°56'57"	1.000	19.34447
Neptune							
9/ 9/1997	17:30	3:02	19h57m38s	-20°16'29"	131°03'36"	1.000	29.47718
9/16/1997	17:02	2:34	19h57m14s	-20°17'46"	124°09'13"	1.000	29.57223
9/23/1997	16:34	2:06	19h56m56s	-20°18'46"	117°14'45"	1.000	29.67534
Pluto							
9/ 9/1997	13:00	0:04	16h13m27s	-8°41'20"	76°58'27"	1.000	30.21389
9/16/1997	12:33	23:33	16h13m51s	-8°45'50"	70°26'33"	1.000	30.32611
9/23/1997	12:06	23:06	16h14m22s	-8°50'27"	63°55'20"	1.000	30.43369

Moon Apsides Report for September 1997

Date	Apsis	Hour	Distance (km)	Diameter
9/ 2/1997	Apogee	17	406473	0.4900°
9/16/1997	Perigee	11	356972	0.5579°

Meteor Showers Report for September 1997

Date	Meteor Shower	ZHR	RA	DEC	Illum. Frac.	Longitude
9/ 8/1997	Piscids	10	0h36m	7°	0.38	166°
9/20/1997	Piscids	5	0h24m	0°	0.78	178°

Twilight Report for September 1997

	Sun		Astronomical		Nautical		Civil	
Date	Rise	Set	Begin	End	Begin	End	Begin	End
9/ 9/1997	7:06	19:53	5:25	21:34	6:00	20:59	6:34	20:26
9/16/1997	7:14	19:40	5:34	21:20	6:08	20:46	6:41	20:13
9/23/1997	7:21	19:28	5:43	21:06	6:16	20:33	6:49	20:00
9/30/1997	7:29	19:16	5:51	20:53	6:24	20:21	6:56	19:48

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SKY & TELESCOPE NEWS BULLETINS

From the editors of Sky & Telescope magazine

HOW NOT TO MAKE THE MOON

At a July meeting held in Cambridge, Massachusetts, planetary scientists learned that making the Earth's Moon with a giant impact isn't getting any easier. The idea that something the size of Mars sideswiped the Earth in its infancy to form the Moon is not new; researchers William Hartmann and Donald R. Davis first offered it in the mid-1970s. The "Big Splat" theory has wide appeal among geochemists because it explains, among other things, the Moon's low iron content and its complete lack of water. But the devil is in the details, and for 20 years dynamicists have struggled to find the right combination of impactor size, collision point, and speed to validate the theory. New computer simulations by Shigeru Ida, Robin Canup, and Glen Stewart show that after the collision, a disk of vaporized material forms. Unfortunately, roughly two-thirds or more of it lies within what's termed the Roche limit (about 12,000 km from Earth's surface) and quickly falls inward. Canup reports that only impacts involving something roughly three times the size of Mars creates a disk massive enough to deposit a Moon's worth of matter outside the Roche limit. The catch, she says, is that the Earth-Moon system is then left with about twice the angular momentum it has today — a dynamical excess that's hard to eliminate. Details will appear in a forthcoming issue of SCIENCE.

GRAVITY BRINGS IN MOST DISTANT GALAXY

With the help of a giant gravitational lens, an international team of astronomers has discovered the farthest, earliest galaxies yet seen. Last year, a group led by Dutch astronomer Marijn Franx directed the Hubble Space Telescope to gaze at a cluster of galaxies several billion light-years away in Ursa Major. This revealed an unusually red arclike object. The researchers presumed the arc to be a much more distant background galaxy whose light was being bent by the cluster's gravity. Now spectra taken with the Keck reflectors have confirmed this supposition and established a redshift of z = 4.92 for the galaxy — the highest value yet measured for any astronomical object. The previous record held by a recognizable galaxy was 4.41, and the farthest quasar has a redshift of 4.90.

ANOTHER MINOR-PLANET SATELLITE

In 1993, the Galileo spacecraft imaged a satellite to minor planet 253 Ida. Now, another asteroid has a companion. German astronomers Stefano Mottola and Gerhard Hahn have been making a survey of asteroids. Among them is a 3671 Dionysus, an Apollo asteroid that is perhaps only a kilometer wide. An initial light curve made in late May displayed unusual features, leading the astronomers to hypothesize it could have an unseen companion that eclipses it periodically. Mottola and Hahn predicted that similar magnitude dips would be seen again in early June and arranged for other observatories to watch for them. The follow-up observations had the same irregularity at the predicted times, thus confirming that Dionysus has a companion, which orbits in just less than 28 hours.

NEW CIRCUMSTELLAR DISK

On August 6th radio astronomers at Caltech reported their discovery of a young star encircled by a cloud of gas and dust. The star, designated MWC480, lies about 450 light-years away form us in Auriga. It is brighter and more massive than our Sun. Astronomer Vince Mannings explains that not only did he and his colleagues uncover the ring of material, but also unambiguously discern its motion around the star. Such an orbiting cloud would be long-lived, says Mannings, which could last long enough to form planets. Details will appear in the journal NATURE.

SPYING ON MIRA

The Hubble Space Telescope has taken a close view of the first-known variable star. Margarita Karovska and others took ultraviolet and visible light views of Omicron Ceti — also known as Mira — and revealed evidence for a companion lying some 70 astronomical units away. The ultraviolet picture reveals an arm of material that may be gas drawn off the outer atmosphere of Mira by the companion, or just a hot spot illuminated by the companion. The visible-light views depict an irregularly shaped Mira. The astronomers note that this could be a consequence of the star's expansion and contraction or due to sunspot-like regions in its outer layers.

CLYDE TOMBAUGH MEMORIAL

Richard Jones, a member of the Astronomical Society of Las Cruces, New Mexico, reports that the church Pluto-discoverer Clyde Tombaugh and his wife Patsy helped found is trying to raise funds for a memorial stained glass window in honor of Clyde. You'll find more information at http://www.zianet.com/silvern/clyde.htm.

(continued on page 8)

(continued from page 7)

PERSEID PEAK DAZZLES

Of the reports of the Perseids reaching SKY & TELESCOPE thus far, most have said that the meteor shower was fairly lackluster until the time of predicted peak, at around 8:15 Universal Time, or 4:15 a.m. Eastern Daylight Time, August 12th. In this predawn period, observers reported an average of at least one Perseid per minute. According to Joe Rao, who was watching the skies in upstate New York, he followed a meteor train for more than a minute with 7x35 binoculars and reports a "bunching" of meteors — as many as 6 Perseids appearing within a minute. George Zay notes similar results from Southern California, where he saw 75 Perseids between 9:00 and 10:00 UT. The one-per-minute average continued for the next two hours.

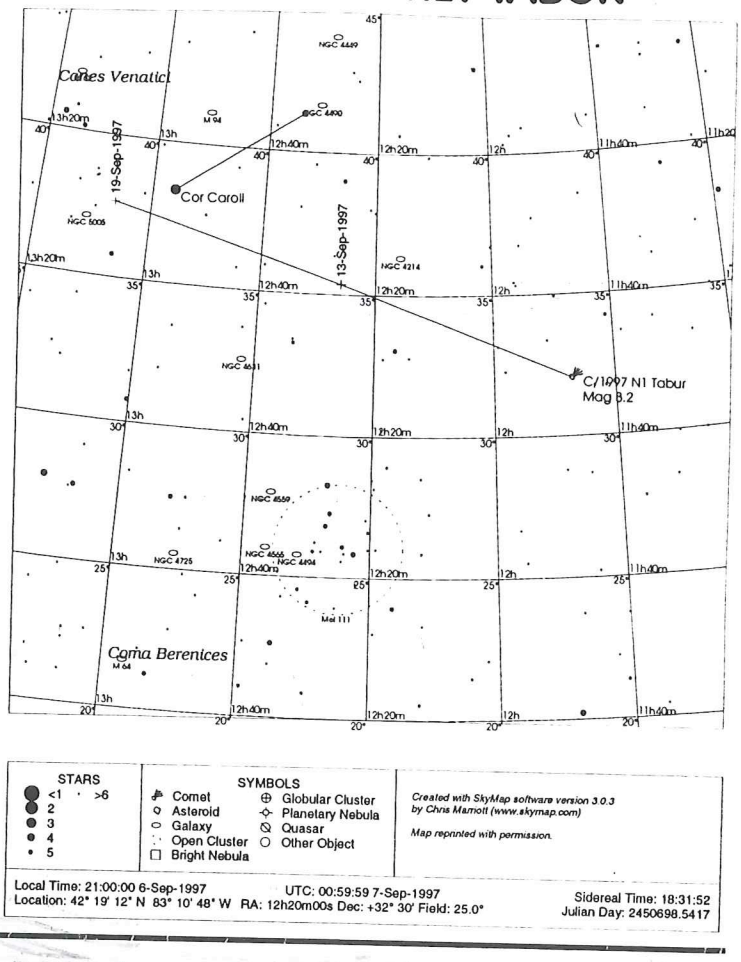
A BOOMERANG FIREBALL

Speaking of bright meteors, one of the most celebrated fireballs of modern times turned 25 this past month. On the afternoon of August 10, 1972, a spectacular meteor streaked across Rocky Mountain skies for 1,500 kilometers, startling thousands of onlookers in the western United States and Canada. Home-movie footage immortalized the event. This and other photographs — plus data from a military satellite — led dynamicists to conclude that the 10-meter-wide cosmic visitor had actually skipped through the atmosphere, coming as close as 58 km to Earth's surface before returning to space. According to recent calculations by Martin Connors at the University of Alberta, the body has a 1.79-year orbit that brings it back to Earth's proximity sometime in July or August. This time around, however, the giant rock should come no closer than 8 to 10 million kilometers.

NEW INSTRUMENT FOR HUBBLE

A $25-million ultraviolet spectrograph has been selected by NASA for the fourth Hubble Space Telescope servicing mission, currently scheduled for 2002. The University of Colorado at Boulder and Ball Aerospace & Technologies Corp. designed the Cosmic Origins Spectrograph (COS) to obtain ultraviolet spectra of faint objects. While promising to shed light in several arenas, from stellar atmospheres to the local interstellar medium, COS's principal mission is to measure the density, composition, and ionization state of intergalactic gas clouds billions of light-years away. Doing so should provide scientists with new insights into the nuclear reactions that took place shortly after the Big Bang; they may also be able to better pin down the overall cosmic density of baryons (ordinary matter particles) — a crucial cosmological parameter. ☆

FINDING COMET TABUR



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