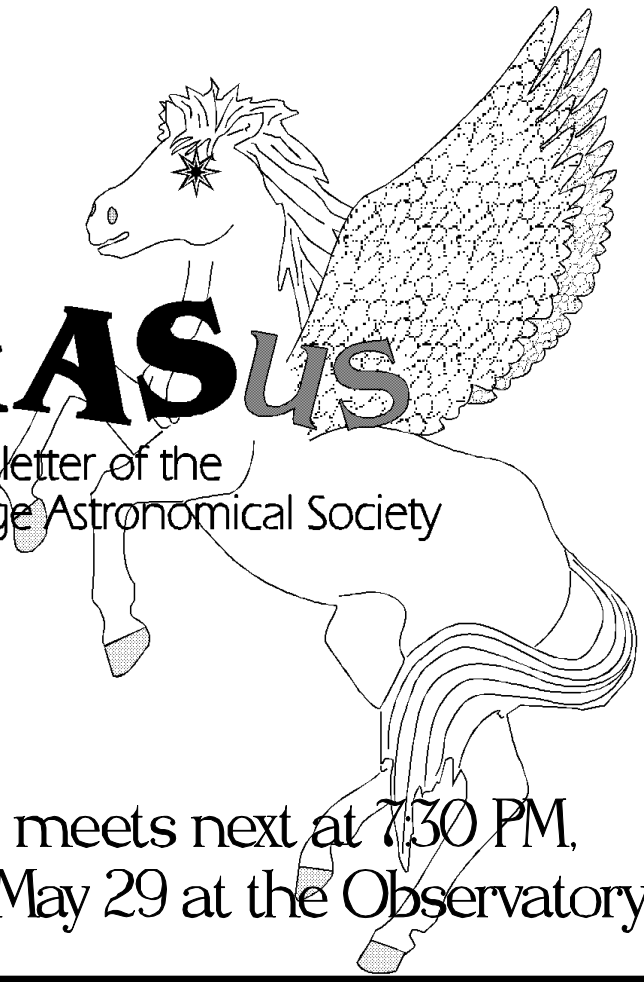
1996 MAY Issue #66

the PeGASus

Newsletter of the
The Prince George Astronomical Society



The PGAS meets next at 7:30 PM,
Wednesday, May 29 at the Observatory.

INSIDE :

the PeGASus is published monthly by the *Prince George Astronomical Society*.

Our pursuits are out of this world.
Our activities are astronomical.
Our aim is the sky.

Contributions to the newsletter are welcome.
Deadline for the next issue is June 10

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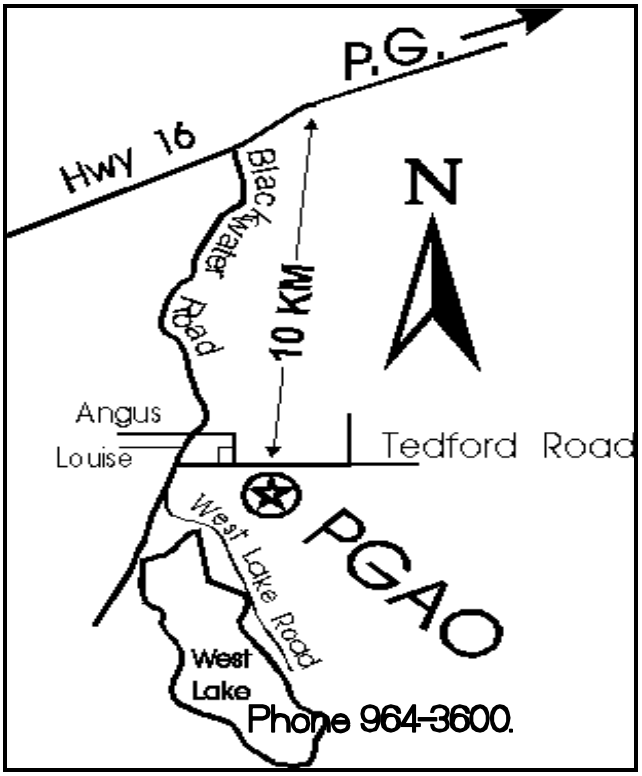

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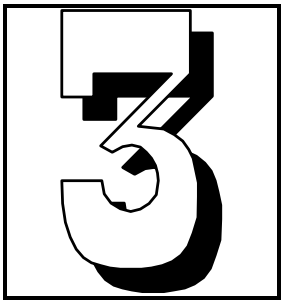
Editorial



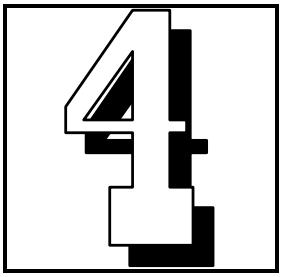
by Orla Aaquist

Some of you may be wondering what happened to the ***PGAS Contributors List*** usually printed on page 15 of this newsletter. It is still part of the newsletter, but has been moved to the side to make room for articles.

Every month I receive a copy of SKYNEWS, the newsletter of the RASC Victoria Centre. I glance through it to see if there are any articles worth stealing. To my surprise, in the May issue of SKYNEWS, I spotted my April editorial wherein I rambled on about how hard science was. That felt good. It's nice to see evidence of others enjoying our efforts. You, too, can get this nice feeling if you write some articles for the PeGASus. A recent survey showed that at least seven people read this newsletter.

I finally discovered the proof that extraterrestrial beings are visiting the earth. Add up the deficit of every country in the world and ask the question, "Just who do we owe this money to?" Now, there are only a few countries in the world which are not in debt (I think New Zealand is one). and, surely, the existing grand total debt is not owing to these few countries. So, we must owe the money to someone else. Well, guess what, there isn't anyone left. QED.

Lastly, have you ever noticed that the closer you look at something, the more complicated it gets? On the other hand, if you don't look too closely, most things are pretty simple. It is possible to go through life without paying much attention to details. The world is set up that way. We see only the surface of a seemingly stable world. Beneath this stability is a chaotic world of forces, movement, particles, energies, relationships and interactions, causes and effects. On the large scale, we see unchanging stars. But these stars are not just point of light, they are suns. Suns are not just balls of hot gas, they are thermonuclear generators. If you want adventure into the unknown, you do not need move at all. Look at anything or examine any event and ask why and how. If you pursue these questions, you have created lifetimes of work. Dare to look at the world. Dare to look inside yourself. Anything can be questioned, including the question itself; ncluding the ability to ask questions; including the ability to ask questions about questions ... pause. For the most part, it gets us nowhere, but once in a while someone invents a telescope.



Coming Events

If you are involved with any astronomical or otherwise scientific activity on behalf of the PGAS, please list the activity here.

May 24 -Friday night observing.
May 29 -PGAS monthly meeting at Observatory. This meeting will be a telescope workshop. Learn all about telescopes, how to set them up and use them. Learn how to use the club's 10", C8, small refractor, and 24". If you have a small telescope in your closet and you don't know how to use it, bring it along.
May 31 -Friday night observing. This is the last observing session for the season. Observing starts up again on August 2.
June 19 -Galilean satellites dance across Jupiter
June 26 -PGAS monthly meeting at the observatory. This is the last meeting of the season.
June 27 -RASC General Assembly in Edmonton
June 29/30 -PGAS participation with Canada Day?
August 11 -Perseid Meteor Shower Party. Perseids peak at 5AM on the morning of August 12.
August 24 -Club BBQ at the observatory. Starts at 5:00.

On **July 12,** there will occur a spectacular dark limb reappearance of Venus from behind the moon. Bermuda is the best place to observe this event. If you are planning your summer vacation to that area, keep an eye open for it. Time of occurrence is 4:29 AM local Bermuda time.

Comet Hale-Bopp reaches perihelion on **April 1, 1997.** It is currently visible in the morning sky. See article on page 9 for details.

The closest total solar eclipse to North America visible from land until the year 2017 will occur on **February 26, 1998.** Start planning your 1998 vacation to Palm Beach, Florida now. The eclipse will last 3.5 minutes. Jupiter will be 2 degrees and Mercury 4 degrees away from the eclipse, and should be visible within the sun's corona.

Announcements

New Members: Please welcome **Wayne Crawford** (562-9042) and **Marjorie Topp** (964-6044) of Prince George to the PGAS. If you are going observing, give Wayne and Marjorie a call and invite them along.

Alberta Star Party: The RASC Calgary and Edmonton Centres have announced the 10th annual Alberta star party to be held on **September 13 to 15** at Eccles Ranch, Caroline, Alberta. Caroline is located near Red Deer, about half way between Edmonton and Calgary. The Caroline site has wonderful dark skies. A general information brochure is available at the observatory (or call Orla at 964-9626).

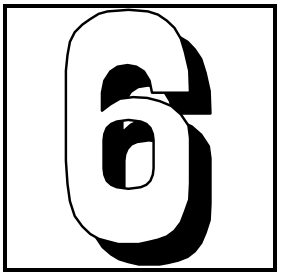
PGAS Joins the WWW: Mathew Burke and Dave Kubert have set up a *World Wide Web* home page for the PGAS at UNBC. Mathew has done most (or all) of the work creating the web page, and Dave is responsible for installing it on the English Department's computer Adreaeas. Thanks to Dr. Stan Beeler (professor of English, UNBC), for giving us access to this computer. Our web address is

http://andreae.unbc.edu/kubert_html/PGAS/

Mathew can be reached at *Avro100@Netbistro.com*

Congratulations to Alan Whitman for his article "*The Big Dipper: Centerpiece of the May Sky*", published in the May/June issue of Skynews.

And Baby Makes Three: Susan and Mathew Burke are going to have a baby! For those who like to check the 9 months statistic, they 'tied the knot' on December 31.



The Night Sky

Perpetual Twilight

by Alan Whitman

Well, it's time for my annual lament about latitude 54's twelve weeks of endless twilight. But August will come! It isn't so tough to take this year since I'm confident that I'll have a new observatory at latitude 44 by next summer. Let's see, my Observer's Handbook says that on the shortest night, June 21st, I'll still have 3 1/2 hours of true darkness then and Scorpius will ride the meridian at local midnight (all of it, even the lowest sweep of the tail which can never rise in B.C.) Okay, okay ... but it is a pretty long time before precession allows it.

So, what is visible despite our bright northern semi-night? Start with the huge crescent Venus, now grown so large that the crescent should be visible in rigidly held binoculars (prop your elbows on a railing or car roof). But look early, around sunset or before, so that Venus is high enough to give a reasonably steady image. A bright sky will also suppress Venus' intense glare and give a much better view of the crescent. From the Observer's Handbook, here are Venus' vital statistics:

Date		illumination	Diameter	Elongation from sun
May	25	8.8%	50.7"	24 deg
	29	5.5	53.3	19 deg
June	2	2.7	55.5	13 deg
	6	0.8	57.1	7 deg

Venus reaches inferior conjunction (passes between earth and the sun) on June 10th. It will become progressively more difficult to observe as it closes on the sun but it is worth the effort--Venus' extremely thin crescent is far more interesting than any other phase. If you pick up Venus before sunset, careful inspection should show that it is more than 180 degrees from cusp to cusp, probably about 200 degrees by early June. This is because Venus' very thick atmosphere scatters sunlight into the night side.

By June 23rd you should be able to recover Venus low in the dawn sky with Mercury in conjunction, only 1.6 deg to the north.

Jupiter rises by late evening in June. Don't miss the wonderful sight on the night of June 19-20 of both Ganymede and Europa and their shadows crossing Jupiter's disk simultaneously while Io gets eclipsed. Put this transit extravaganza in your day planner:

11:55 PM PDT Ganymede's shadow starts to transit Jupiter's disk
12:01 AM PDT Europa's shadow starts to transit at the planet's east limb (a total solar eclipse path across Jupiter)
12:15 AM PDT Io is eclipsed by Jupiter's shadow (Io is the only moon

west of the planet while Europa and Ganymede are approaching the east limb and Callisto is far east)
12:41 AM PDT Europa starts to transit across Jupiter (Europa's tiny white disk will be most visible at Jupiter's limb or if transiting a dark belt but will disappear if in front of a Jovian bright area)
1:19 AM PDT Ganymede starts to transit (easier to see than Europa)
2:47 AM PDT Europa's shadow transit ends at Jupiter's west limb
2:50 AM PDT Orange Io reappears from occultation at the east limb
3:01 AM PDT Ganymede's shadow leaves the disk at the west limb
3:28 AM PDT Europa leaves the disk at the west limb
4:26 AM PDT Ganymede leaves the disk and Jupiter is again accompanied by four moons rather than only Callisto as was the case at 2 AM.

Poor seeing at Jupiter's low altitude may make it tough to see some of the transits but its worth a try. The satellites' pure black shadows are much easier to see in transit than the satellites themselves. Ease of visibility will change during each transit depending on the varying contrast between the transiting object and the Jovian disk. Give this a try, its potentially a lifetime memory!

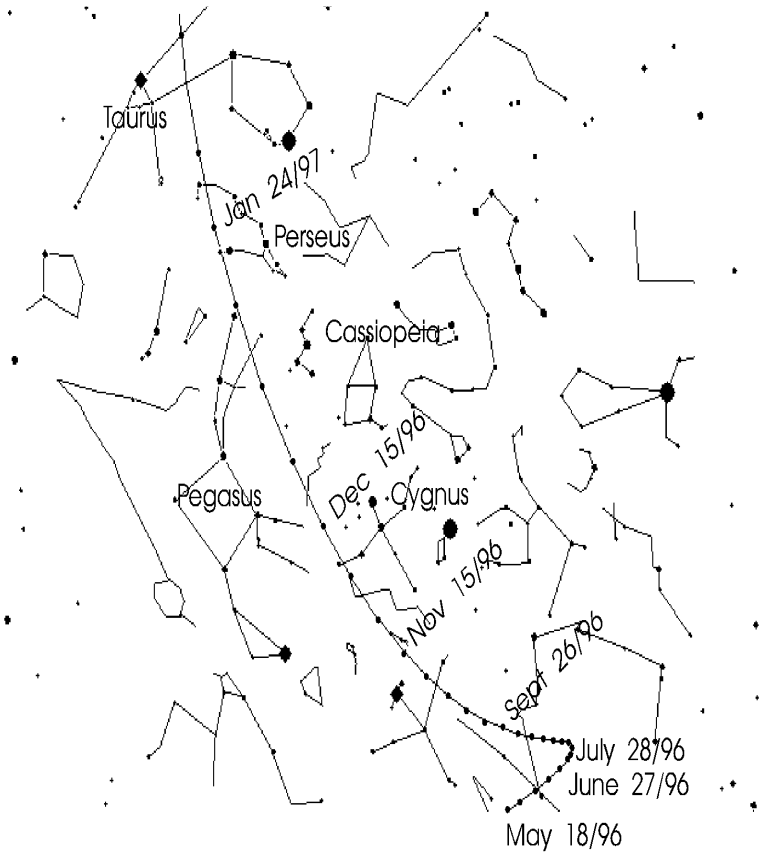
Saturn is in Cetus. (First Ophiuchus crashed the zodiacal twelve and now Cetus--where is the respect for tradition?) Saturn crossed the celestial equator May 25th and will be north of the equator for 15 years--our turn! Look forward to Saturnian oppositions high up in Taurus and Gemini early in the next millennium, with the rings fully open and the planet reaching negative magnitudes, about mag -0.3.

What else is there to see? Certainly neither galaxies nor nebulae will show much in June but stars don't suffer as much from deep twilight. Try deep sky objects consisting of stars, open and globular clusters. The 24" spends a lot of time on M13 but how often do you swing a little farther north in Hercules to M92? In an 8", M92 looks somewhat rectangular but not in the 24". The other 'first rank' globulars of late spring are M3, M4 (one of the closest globulars), and M5 (every bit the equal of M13). Just a step behind and well worth a look are M10 and M12, only 3 deg apart in Ophiuchus.

If you get a steady night, look at M4 with the Celestron 8. It has a remarkable bar of brighter (mag 11) stars bisecting the central mass. The 24" brings out so many stars that the bar becomes less prominent than in a smaller instrument. M4 is the only globular that Messier's crude telescopes were able to resolve into stars. The big cluster is only 1.2 deg west of Antares. Between them, 0.7 deg NW of Antares, is a tiny mag 10 globular, NGC 6144. The 24" resolves it into 14th mag stars. Can you spot NGC 6144 in an 8"? An 8" should normally reveal a 10th magnitude globular but I've never been able to overcome the glare of Antares.

Comet Hale-Bopp is currently coming out of conjunction with the Sun in the morning sky. As the year continues, it should slowly brighten making it easier to find. For the next few months the comet will be mainly a morning object . By summer, the comet will be visible most of the night and will be bright enough to be seen in binoculars.

The orbit is inclined nearly 90 degrees from the ecliptic. The comet will come up from the south, go over the top of the Sun and then plunge down again. This means that the comet will be best seen from the Southern Hemisphere (and lower Northern latitudes) except when it is expected to be at its brightest. In March and April 1997. The comet will make its closest approach to the Earth on March 23, 1997. At that time, the comet will be more than 194 million kilometers from Earth, much farther away than Hyakutake whose closest approach was 15 million kilometers. Following is a calendar of events for Hale-Bopp. The accompanying map on the right shows its approximate location in the sky.



Path of Hale-Bopp
10 day increments

March 1996-July 1996: Visible in small telescopes and binoculars.

August 1996: Experienced observers (like Alan Whitman) will be able to detect the comet with the naked eye. Easy object in binoculars.

September-November 1996: Brightens slowly as it moves northward and toward the Sun. It might be sighted by general public with assistance from experienced observers.

December 1996-January 1997: Brightens rapidly, but comet is within 38 degrees of the Sun. Difficult object for general public because it will be very low in the sky when visible.

February-early March 1997: Remains low, but has become a bright object. It should be easy to find given reasonable instructions.

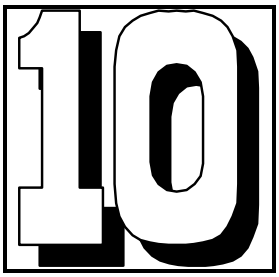
late March - early April 1997: Comet should be at its best. It is expected to be near its peak brightness, and is at its farthest declination north. The best dates for observing the comet should be March 26 - April 12, with minimum interfere from the moon.

Late April-June 1997: In late April, the Moon will interfere. Comet will move south and closer (in the sky) to the Sun. It will also fade significantly, but the tail development should peak in May or June. Although, it will be lost by the general public in the Sun's glare, experienced observers might be able to follow it.

July - September 1997: Moves away from (but is still close to) the Sun in the morning sky. The comet is moving rapidly towards the south and continues to fade. Northern Hemisphere observers lose the comet during this period.

October - December 1997: The comet is lost from naked eye visibility. It may be lost earlier due to its location close to the Sun.

This article was condensed from the article, "Information on Comet Hale-Bopp for the Non-Astronomer" by Charles Morris http://encke.jpl.nasa.gov/index.html



Pi Equals Three

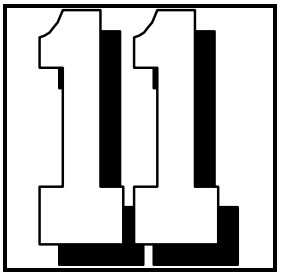
by Orla Aaquist

On May 3, upon attending a CNC lecture by Dr. Peter Borwein, co-director of the *Centre for Experimental and Constructive Mathematics* at Simon Fraser University, I learned that the first estimate of pi is found in the Old Testament in The First Book of the Kings (7:23): "***And he*** (King Solomon***) made a molten sea, ten cubits from the one brim to the other: it was round all about, and his height was five cubits: and a line of thirty cubits did compass it round about***." If you divide the circumference (thirty cubits) by the diameter (ten cubits), you get the value of three.

Pi is defined to be the ratio of the circumference to the diameter of a circle. Its value is independent of the size of the circle or whatever units are chosen to measure its size. You can estimate the value of Pi by drawing any circle and measuring its diameter and circumference. The circumference is a little harder to measure than the diameter, and I'll leave it to the inspired reader to determine the best way to do it. A common calculator has the value of Pi, 3.1415927, stored in memory; however, this is only an eight digit approximation of Pi. The sequence of numbers go on indefinitely, with the digits 0 to 9 appearing in a totally random fashion.

Using modern computers and recently developed mathematical algorithms, the value of Pi can now be calculated to billions of decimal places. According to Peter Borwein, the 40-billionth digit of Pi is 1.

RASC General Assembly



*T*he Edmonton Centre is hosting this year's General Assembly on the University of Alberta campus from June 27th to July 1st, 1966. Eleven years have passed since the society last met here, and Edmonton has gone through major changes in that time. We would like to take this opportunity to invite all members of the society to Edmonton for the General Assembly.

The *Helen Sawyer Hogg Memorial Lecture* will be given by Dr. Werner Isreal. Dr. Isreal's lecture is entitled "From White Dwarfs to Black Holes" and will address the evolution of relativistic astrophysics in the twentieth century.

Numerous tours will be available on Canada Day, as well as functions at the Edmonton Space & Sciences Centre on Friday, including access to the Challenger Centre. Sunday morning we will be at Fort Edmonton Park, a historic theme park that recreates life in historic Edmonton, and the annual banquet on Sunday night will be featuring an Alberta specialty.

Registration packages are available on the World Wide Web from

http://valis.worldgate.edmonton.ab.ca/~banonay/RASC/index.html

Or you can phone (403) 469-9765, send e-mail to howardg@ibm.net or linda.forbes@ualberta.ca, or send snail-mail to RASC GENERAL ASSEMBLY '96, c/o 8831 - 93 STREET, EDMONTON AB T6C 372.

Editor's Note: *I have accessed the WWW information and will have copies of the registration material available at the May meeting of the PGAS. Or call me at home, 964-9626. Let me know if you plan to go. Perhaps we can make it a group thing.*

Tortured Science

by Orla Aaquist

I thought that you might enjoy the answer given by a student to one of my final exam questions in Astronomy 105.
Question: There are several types of celestial objects found in our galaxy: main sequence stars, red giant stars, white dwarfs, neutron stars, planetary and other types of bright and dark nebulae. Through a discussion of stellar evolution, explain how these various types of objects are related.

Student's Answer: There was a big bang in the universe about 4.6 billion years ago and along came stars. They (there) are quite a number of stars in today's universe. There are some that are red giants and some white dwarfs and some bright ones and some real dim stars when they are shown through a stretoscope (telescope?). The main sequence of stars, showing when a star passes through the various stages. First a star becomes a white dwarf. At this stage the luminosity of the star is at its highest and the electrons and positive neutrons are flowing freely so that the star has a chance to light up brightly in the night sky, but as the neutrons, protons, and electrons begin to lose their brightness and diameter as they begin to slow the electrons flowing process down. Then it moves into the nebula stage where it is a very bright blue star and the electrons are limited now and not as free-flowing. We then see a stage after the nebula where the stars become a red giant. In the red giant the luminosity is at it's highest. The electrons shift the red shift and become negative. This is when the concept of planetary motion kicks in. The star may then explode or it could just become interstellar dust which may be seen with our eyes through a telescope. The red dust may then be absorbed through a absorption line which we may also see through a telescope. These objects are all tied together in the universe with such a bound that they all pass through the various stages to becoming either red giants or big nebular stars that light up the huge night sky.

AstroSurfing

Details of the Science News posted here are available on the astronomy forum on the Prince George Free-Net.

HEART OF THE "GREAT ATTRACTOR": An international team of observers has found what may be the attractor's core along the Circinus-Centaurus border. A previously known cluster of galaxies, Abell 3627, appears to be the richest galaxy cluster in the southern sky. The team has estimated the cluster's mass at a hefty 5 million billion Suns.

A NEW MATERIAL, zirconium tungstate compound (ZrW_2O_8), shrinks when heated over a wide temperature range, from 0.3 K up to 1050 K. Previously known shrinking materials, like water, have done so only over a small temperature range, or have shrunk anisotropically. An important role for the material would be as a component in composite materials where is to desirable to keep thermal expansion to a minimum.

ANOTHER NEW PLANET: Glance slightly eastward along the ecliptic to the constellation Cancer, where another planet outside our solar system has been discovered. The team of California astronomers who reported finding a couple of planets in Virgo and Ursa Major (and confirmed the existence of the one in Pegasus), have bagged another one. As part of an ongoing survey of 120 Sun-like stars, Geoffrey Marcy and Paul Butler examined 55 Cancri. Their spectroscopic observations of the 5.3-magnitude G8 star's radial velocity revealed that it is circled by a mass of no more than 80 percent that of Jupiter, every 14-3/4 days. The new planet orbits at a distance of 16.5 million kilometers, less than a third of the average distance between the Sun and Mercury. At that distance, Marcy notes that the surface temperature of the planet would be about 500 degrees Celsius. 55 Cancri is located at Right Ascension 8 hours 52.6 minutes, Declination +28.3 degrees, about 15 degrees to the upper left of the star Pollux.

EXTENSIVE OBSERVATIONS OF SATURN'S EDGE-ON RINGS have been made by The Hubble Space Telescope. Some findings: the ring system overall is about 1.2 to 1.5 km thick; the F ring is inclined relative to the A ring; the rings are covered by a tenuous sheath of OH molecules; the tiny inner satellite Prometheus was some 19 degrees of longitude away from its estimated position; the E ring flares (at a distance of 7.5 Saturn radii) to a thickness of about 15,000 km.

THE FIRST BINARY-STAR SYSTEMS BEAMING X RAYS AT SUB-MILLISECOND rates have been observed by the Rossi X-Ray Timing Experiment, an orbiting telescope launched in December 1995.

HUBBLE CELEBRATES: It's hard to believe, but the Hubble Space Telescope has been in orbit for six years.

THE EROS WATCH: The asteroid 433 Eros currently has an orbit that brings it close to -- but not across -- the Earth's orbit. However, according to new computer simulations by dynamicists in France and Italy, Eros's orbit is likely to evolve over the next two million years. Don't worry: the immediate threat of a catastrophic collision is extremely small, and we appear to be safe for at least the next 100,000 years.

SOHO: Astronomers have high hopes for a spacecraft called the Solar and Heliospheric Observatory, or SOHO, which was launched December 2nd to begin a long-term study of the Sun. And it's already paying dividends, as the first results were announced on May 2nd. SOHO is supposed to monitor the "quiet Sun" during the minimum in its 11-year activity cycle. But movies made from SOHO ultraviolet data show that the Sun's outer atmosphere, or corona, is surprisingly active. SOHO is on location in space near the L-1 Lagrangian point, where the Earth's and Sun's gravitational forces balance, some one million miles sunward from the Earth. This vantage point enables solar astronomers to observe the Sun continuously, with no intervening "night."

X-RAY FLASHERS: Yet another orbiting observatory is making its mark. Astronomers say the Rossi X-ray Timing Explorer has discovered a trio of objects whose X-ray emissions flicker very rapidly.

IO's METALLIC HEART: A team at the Jet Propulsion Laboratory has concluded

that Jupiter's satellite Io has a large metallic core. The researchers deduced its presence by analyzing tracking data acquired during Galileo's high-speed flyby of the moon on December 7th. The spacecraft also has detected a large "hole" in Jupiter's magnetic field near Io, leading to speculation about whether Io possesses its own magnetic field. If so, it would be the first planetary moon known to have one.

TWO EFFORTS TO MEASURE THE HUBBLE CONSTANT are converging somewhat. Wendy Freedman of the Carnegie Institution, using the Hubble Space Telescope, reports a value in the range 68 to 78 km/sec/Mpc. A separate group led by Allan Sandage, also of Carnegie, recently reported a Hubble constant of 57.

THE OLDEST STARS IN THE MILKY WAY ARE 15 BILLION YEARS OLD. An important adjunct to the debate over the Hubble constant is the notion that the universe cannot be older than its older stars, which appear to be those in globular clusters.

RECORD HIGH LASER INTENSITY: The advent of tabletop terawatt lasers has promoted the study of new nonlinear optical effects. Donald Umstadter of the University of Michigan sends a powerful laser pulse into a sample of argon gas. The leading edge of the pulse rips electrons from the argon atoms. The rest of the pulse interacts with the ensuing plasma, setting up a self-focusing process which results in a laser intensity as high as 10**20 W/cm**2. Furthermore, the laser beam clears a micron-sized path for itself through the plasma. In the act of excluding plasma electrons from this region, pressures probably exceeding 1 giga-bar (higher than any other manmade pressure) are created.

SPACE STATION AIR PURIFICATION SYSTEM COMPLETES MAJOR TEST: The system that will purify the air aboard the International Space Station recently passed a major test at NASA's Marshall Space Flight Center, Huntsville, AL. The month-long test evaluated the system's ability to control carbon dioxide, oxygen and air pressure inside the Station's living and laboratory quarters.

PROGRESS TOWARDS COMPLETION OF NEXT GREAT OBSERVATORY: A major milestone on the road to launch of NASA's next Great Observatory, the Advanced X-ray Astrophysics Facility (AXAF), has been passed with the completion of the High Resolution Mirror Assembly, following the successful application of a special reflective coating to the eight cylindrical mirrors.

THE ACOUSTIC ANALOG OF A LASER is being developed by Jean-Yves Prieur at the University of Paris-South. The active medium in this case is a piece of pure silica at a temperature of 0.5 K. An initial sound pulse "pumps" the sample by depositing acoustic energy at absorbing centers throughout the silica. A second sound pulse stimulates the absorbing centers to reradiate phonons, which serve to amplify the second pulse.

BINARY ASTEROIDS: Doublet craters account for 10% of all impact structures on Earth and Venus. A new study by William Bottke (Caltech) and Jay Melosh (Arizona) shows that the relatively wide separation of craters in doublet events can best be explained by supposing that tidal fragmentation into parts had occurred at some earlier stage, as with Comet Shoemaker-Levy.

CLOSE PASS BY 1996 JA1: A small asteroid measuring 300 to 500 meters across, recently zipped past the Earth. Designated 1996 JA1, it was only discovered on May 14th by observers Tim Spahr and Carl Hergenrother in Arizona. It passed just 450,000 km from Earth on May 19th and got as bright as magnitude 10.5.

FIRST LIGHT FOR KECK II: The second 10-meter Keck telescope was dedicated at a May 8th ceremony atop Mauna Kea in Hawaii. Its twin already ranks as the world's largest optical telescope, but plans call for Keck I and II to be used together as an optical interferometer. The distance between them is 85 meters, a baseline that should provide unprecedented resolution at visual and near- infrared wavelengths. To that end NASA will provide $44 million toward the development of an adaptive-optics system.

HYAKUTAKE DOWN UNDER: Comet Hyakutake hit perihelion on May 1st, and since then has popped into view for those Down Under. Observers say the comet is currently magnitude 3.5 with a nice tail about 3 deg long.

Why Are We Here?

contributed by Bob Nelson
(taken from An Introduction to Modern Astrophysics, by Carroll and Ostlie, p 1321.)

"In our astrophysics class, a student once asked "Why are we here?" The answer was as amazing to us as it was to the class:

"We are here because, more than ten billion years ago, the universe borrowed energy from the vacuum to create vast amounts of matter and antimatter in nearly equal numbers. Most of it annihilated and filled the universe with photons. Less than one part per billion survived to form protons and neutrons, and then the hydrogen and helium that makes up most of everything there is. Some of this hydrogen and helium collapsed to make the first generation of massive stars, which produced the first batch of heavy elements in their central nuclear fires. These stars exploded and enriched the interstellar clouds that would form the next generation of stars. Finally, about five billion years ago, one particular cloud in one particular galaxy collapsed to form our Sun and its planetary system. Life arose on the third planet, based on the hydrogen, carbon, nitrogen, oxygen, and other elements found in the protostellar cloud. The development of life transformed Earth's atmosphere and allowed life to move onto land. Sixty-five million years ago, a fortunate collision with a large meteoroid hastened the demise of the dinosaurs and allowed small furry mammals to take centre stage. Primitive men and women evolved and moved out of Africa to conquer the world with their new knowledge of tools, language. and agriculture. After raising food on the land, your ancestors, your parents, and then you consumed this food and breathed the air. Your own body is a collection of the atoms that were created billions of years earlier in the interiors of stars, the fraction of a fraction of a percent of normal matter that escaped annihilation in the first microsecond of the universe. Your life and everything in the world around you is intimately tied to countless aspects of modern astrophysics."

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