P E R T H O B S E R V A T O R Y

PERTH OBSERVATORY PUBLICATIONS 2003/2004

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PERTH OBSERVATORY PUBLICATIONS
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VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc. JULY 2003

SONGS OF THE STARS - THE REAL MUSIC OF THE SPHERES

The ancient Greeks believed that the planets and stars were imbedded in crystal spheres that hummed as they spun around the heavens, making the "music of the spheres." Pythagoras thought that the orbits of the planets have harmonic relationships.

Johannes Kepler centuries later was so enamoured with Pythagoras' idea that in the early 1600s he spent years trying to discover harmonic relationships among the periods of the planets in their orbits, but ended up proving otherwise.

For nearly 400 years the idea of the music of the spheres languished. But in the 1970s scientists began discovering the sun and other stars actually sing, ringing from sound waves in them that cause them to vibrate, get hotter and cooler, brighter and dimmer, bigger and smaller and change shape. These sound waves cannot get out of the star into the vacuum of space, so we do not "hear" them directly. But scientists can detect that the sounds are there.

Using what is now known as asteroseismology - the seismology of the stars - scientists can "look" beneath the surfaces of the stars right into the utterly unearthly maelstrom of the giant nuclear reactors that make up their cores.

Kurtz's lecture will introduce sound and the physics of musical instruments, and show the seismology of the stars (including an amazing group of the strangest stars in the sky discovered by the lecturer).

Guests also will discover how some singing stars, the Cepheids, helped Edwin Hubble discover the expansion of the universe; they will hear about the possibility of giant "diamonds" the size of the Earth, and they have the chance to hear the stars with their very low frequency sounds shifted up into the audible range.

Professor Don Kurtz was born and raised in San Diego, California and received his PhD in astronomy from the University of Texas. He worked for 24 years in South Africa where he was professor of astronomy at the University of Cape Town. He is now professor in the Centre for Astrophysics of the University of Central Lancashire. He has observed over 1500 nights at observatories all over the world, discovered the entire class of pulsating stars known as the rapidly oscillating peculiar A stars, and has well over 200 professional publications.

He is visiting Perth to lecture on his way to New Zealand for the International Astronomical Union Colloquium 193 on stellar pulsation for which he is the co-chair of the scientific organising committee, and then on the International Astronomical Union General Assembly in Sydney where he is keynote speaker at Joint Discussion 12 on Solar and Solar-like Oscillations.

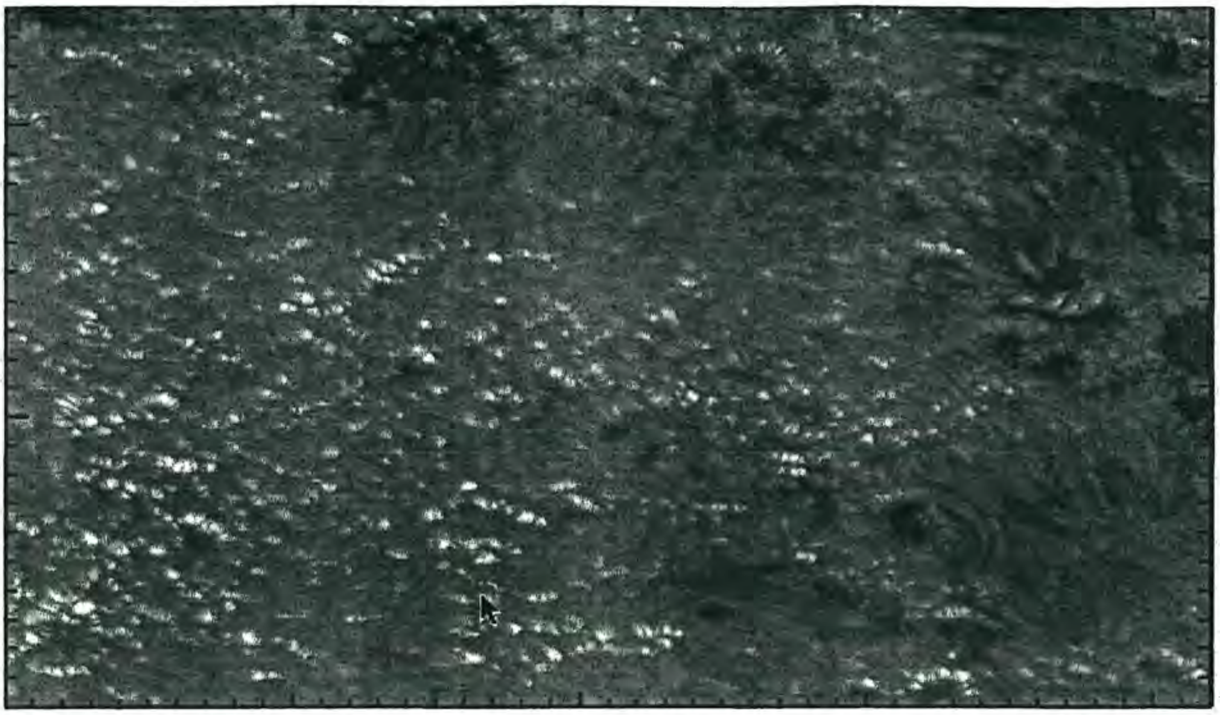
He is past president of the International Astronomical Union Commission 27 on Variable Stars. He enjoys public speaking and has decades of experience lecturing all over the world - on cruise ships, at planetariums, in game reserves in Africa, to business people, as an after-dinner speaker, to schools, in fact, to everyone interested in the wonder of astronomy.

Perth Obs vollies get free entry, but PLEASE BOOK A TICKET.

VENUE: Elizabeth Jolley Lecture Theatre, Curtin Uni (enter the Uni from the SW side)
DATE: Wednesday 2 July 2003
TIME: 7:30pm
COST: $5 (call Perth Observatory to book tickets)
— Dr James Biggs

IN THIS ISSUE:

NEW 3-D PICTURES OF THE SUN



New 3-D images of the Sun billed as the most detailed ever reveal a striking variety of features, astronomers announced today.

The trick in getting the 3-D pictures was to look not at the Sun's central regions but to peer toward the edge, or limb, of the Sun's disk. The effect is similar to staring down at a crowded sidewalk from above and seeing only heads, then looking toward the end of the block and, with a new perspective, being able to see entire bodies.

The images may help theorists understand why the Sun's radiation increases when the star is covered in dark sunspots.

"Until recently we thought of the solar photosphere as the relatively flat and featureless 'surface' of the Sun, punctuated only by an occasional sunspot," said Tom Berger, a solar physicist at the Lockheed Martin Solar and Astrophysics Lab. "Now ... we have, for the first time, imaged the three-dimensional structure of the convective 'granules' that cover the photosphere."

The images were generated by the Swedish 1-meter (3-foot) Solar Telescope on the Spanish island of La Palma. Berger led a study that was presented today at the American Astronomical Society's Solar Physics Division meeting in Laurel, Maryland.

The solar surface consists mostly of an irregular cellular pattern caused by temperature variations. The cells, called granules, are evidence of convection that transports heat to the surface — just like boiling water on a stove. Each granule on the Sun is about the size of Texas.

In the new images, sunspots and smaller dark "pores" are seen to be sunken into the surrounding granulation. The features had been inferred but never imaged directly. Granulation in regions of smaller magnetic fields outside of sunspots is both raised up and has brighter walls than the granulation in non-magnetic regions. Bright structures near the limb of the Sun have been seen for centuries and are called faculae. Scientists think faculae brightness fluctuations correspond to increased solar radiation during periods of maximum solar magnetic activity.

At solar maximum — the peak of an 11-year cycle — the Sun has more sunspots, which tend to be dark. It might seem logical that less radiation would reach Earth. Instead, radiation increases. Scientists suspect the bright faculae near the limb of the Sun to be the source. Models suggest that small magnetic micropores act as tiny holes in the surface of the photosphere.

Figuring this out requires looking at the limb, or edge of the Sun. When looking at center of the Sun's disk, astronomers see only the relatively cool "floors" of the micropores. When seen at an angle near the limb, the models predict that the "hot walls" of the magnetic holes should shine brightly compared to the relatively cooler surrounding granules. The new observations confirmed this.

Most of the bright structures seen are between 93 and 249 miles (150 and 400 kilometers) tall. Simultaneous measurements of the magnetic field establish that the bright faculae are exactly aligned with the magnetic fields, researchers said.

http://www.space.com/scienceastronomy/3d_sun_030618.html

MARS ORBITER EYES PHOBOS OVER PLANET'S HORIZON

Images from the Mars Orbiter Camera aboard NASA's Mars Global Surveyor capture a faint yet distinct glimpse of the elusive Phobos, the larger and innermost of Mars' two moons. The moon, which usually rises in the west and moves rapidly across the sky to set in the east twice a day, is shown setting over Mars' afternoon horizon.

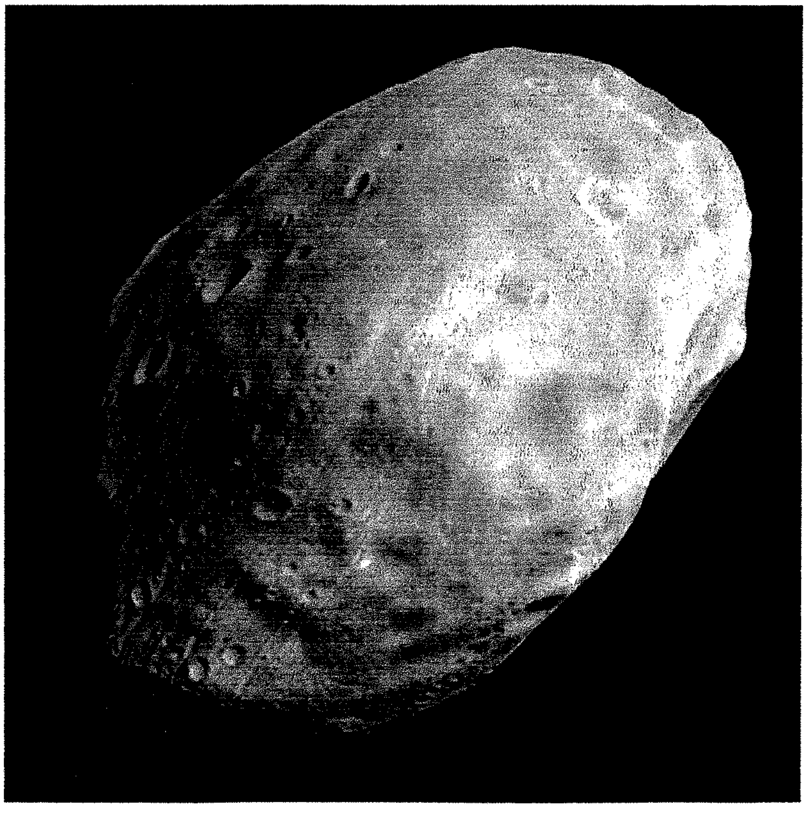
Phobos is so close to the martian surface (less than 6,000 kilometers or 3,728 miles away), it only appears above the horizon at any instant from less than a third of the planet's surface.

From the areas where it is visible, Phobos looks only half as large as Earth's full moon. Like our satellite, it always keeps the same side facing Mars. The tiny moon is also one of the darkest and mostly colorless (dark grey) objects in the solar system, so for the color image two exposures were needed to see it next to Mars. The faint orange-red hue seen in the wide-angle image is a combination of the light coming from Mars and the way the camera processes the image.

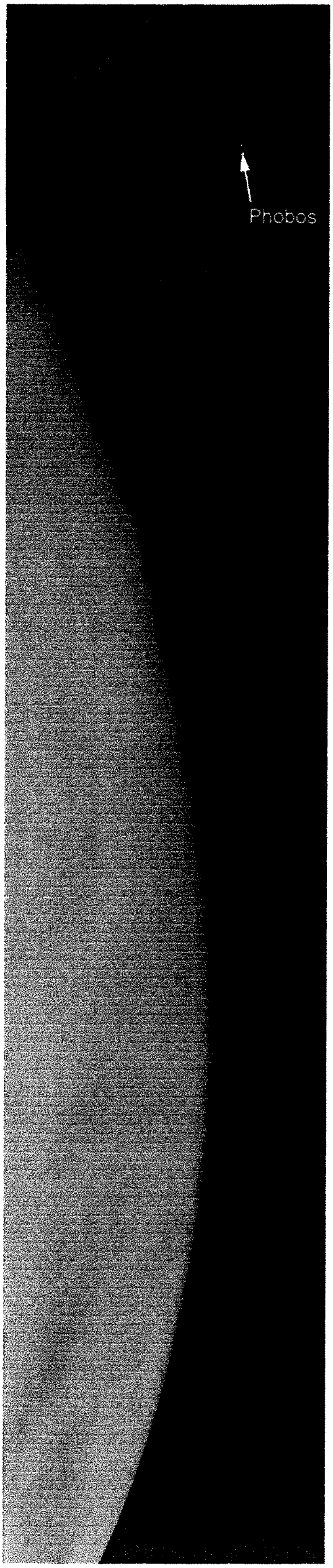
On June 1, the Mars Global Surveyor spacecraft was slewed eastward to capture these views of the inner moon, Phobos, shortly before it set over the afternoon limb. Credit: NASA/JPL/Malin Space Science Systems

http://spaceflightnow.com/news/n0306/24phobos/

The top picture is a high-resolution image that shows Phobos' "trailing" hemisphere (the part facing opposite the direction of its orbit). At a range of 9,670 kilometers (6,009 miles), this image has a resolution of 35.9 meters (117.8 feet) per pixel. The image width (diagonal from lower left to upper right) is just over 24 kilometers (15 miles).



A high resolution image of Phobos was taken by Mars Global Surveyor from about 6,010 miles away. Credit: NASA/JPL/Malin Space Science Systems



OUT OF ROUND SURPRISINGLY FLAT STAR FOUND

Stars are commonly thought to be round, but astronomers have long known this is never quite true. Even Earth, owing to its rotation, bulges a bit at the midsection. New observations, however, have detected the flattest star ever. The fast-spinning star is about 50 percent wider at its equator than if measured from pole to pole. The standard model of stellar composition and rotation --which assumes solid-body rotation and a mass concentration at the centre of the star -- can't account for the extreme out-of-round shape. Researchers said the finding presents "an unprecedented challenge for theoretical astrophysics."

The star, called Achernar, is about six times more massive than the Sun. It sits 145 light-years away in the Southern Hemisphere constellation Eridanus, the River. The results will be published in the journal Astronomy & Astrophysics. -- Dr James Biggs

The latest news from Astronomy Now and Spaceflight Now

FOAM 'MOST PROBABLE' CAUSE OF COLUMBIA DISASTER

A member of the Columbia Accident Investigation Board said Tuesday, for the first time, that a foam strike during the shuttle's launching is the "most probable cause" of the disaster.

He also said analysis of recovered debris indicates a large portion of the ship's left wing broke off in the shuttle's final seconds at the point where the catastrophic breach occurred.
http://spaceflightnow.com/shuttle/sts107/030624cause/

SPACEFLIGHT NOW INTERVIEWS STATION'S RESIDENT CREW

The international space station's Expedition 7 crew — commander Yuri Malenchenko and science officer Ed Lu — spent about 20 minutes talking with Spaceflight Now's Steven Young on Tuesday in an exclusive live interview. The interview is presented here in its entirety.
http://qs240.pair.com/sfnvideo/video/0306/030624issevent_qt.html

SOHO ENGINEERS BATTLE TO OVERCOME ANTENNA PROBLEM

One of the world's premiere Sun-watching observatories has suffered a glitch that threatens to hamper its future studies of our nearest star.
http://spaceflightnow.com/news/n0306/22soho/

DELTA AQUARIDS

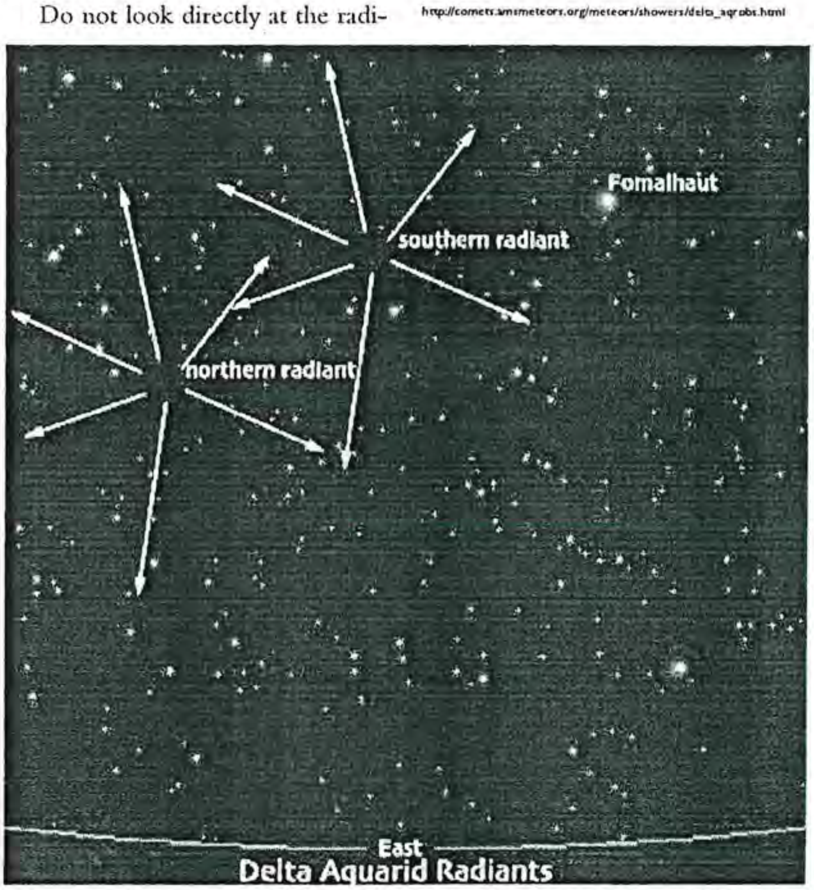
The Delta Aquarids are better seen by observers in the Southern Hemisphere, both because of the radiant's higher altitude and because it is winter, with more transparent skies. To best observe the Delta Aquarids wear appropriate clothing for the weather. In the Southern Hemisphere, the radiant will eventually reach a very high altitude, so it is recommended that you align your lawn chair with feet pointing either north or south, and set the center of your gaze to a point between 45° and 60° above the horizon.

Do not look directly at the radiant, because meteors directly in front of you will not move much and fainter ones might be missed. Decent numbers of Delta Aquarids can be seen after midnight local time.

The Radiant

The duration of the southern Delta Aquarid meteor shower covers the period of July 14 to August 18. Maximum currently occurs on July 29/30 (solar longitude=125 deg), from an average radiant of RA=339°, DEC=-17°. The maximum hourly rate typically reaches 15-20.

http://comets.amsmeteors.org/meteors/showers/delta_aqrobs.html



This represents the view from mid-southern latitudes at about 11:00 p.m. local time around July 31. The red line across the bottom of the image represents the horizon.

UNIVERSE SLIGHTLY SIMPLER THAN EXPECTED

The universe just became a little less mysterious. Using images from the Hubble Space Telescope, astronomers at the University of Florida have concluded that two of the most common types of galaxies in the universe are in reality different versions of the same thing. In spite of their similar-sounding names, astronomers had for decades considered "dwarf elliptical" and "giant elliptical" galaxies to be unique.

The findings, fundamentally alter astronomers' understanding of these important components of the universe, making it easier to understand how galaxies form in the first place. "This helps to simplify the universe because we replace two distinct galaxy types with one," said Alister Graham, a UF astronomer and lead author of the paper. "But the implications go beyond mere astronomical taxonomy. Astronomers had thought the formation mechanisms for these objects must be different, but instead there is a unifying construction process."

Galaxies, the building blocks of the visible universe, are enormous systems of stars bound together by gravity and scattered throughout space. There are several different types, or shapes. For example, the Milky Way galaxy, in which the Earth resides, is a "spiral" galaxy, so named because its disk-like shape has an embedded spiral arm pattern. Other galaxies are known as "irregular" galaxies because they do not have distinct shapes. But together, dwarf and giant elliptical galaxies are the most common.

For the past two decades, astronomers have considered giant elliptical galaxies, which contain hundreds of billions of stars, and dwarf elliptical galaxies, which typically contain less than one billion stars, as completely separate systems. In many ways it was a natural distinction: Not only do giant elliptical galaxies contain more stars, but the stars also are more closely packed toward the centers of such galaxies. In other words, the overall distribution of stars appeared to be fundamentally different.

Graham with Rafael Guzmán, decided to take a second look at the accepted wisdom. The pair analyzed images of dwarf elliptical galaxies taken by the Hubble Space Telescope and combined their results with previously collected data on over 200 galaxies. The resulting sample revealed that the structural properties of the galaxies varied continuously between the allegedly different dwarf and giant galaxy classes; in other words, these two types were just relatively extreme versions of the same object—putting to rest a "very puzzling" question.

In astronomy, like in physical anthropology, there is a deep connection between the classification of species and their evolutionary connections. The bottom line is that the new work of Graham and Guzmán has made life a little bit simpler for those of us who want to understand how galaxies are formed and have evolved.

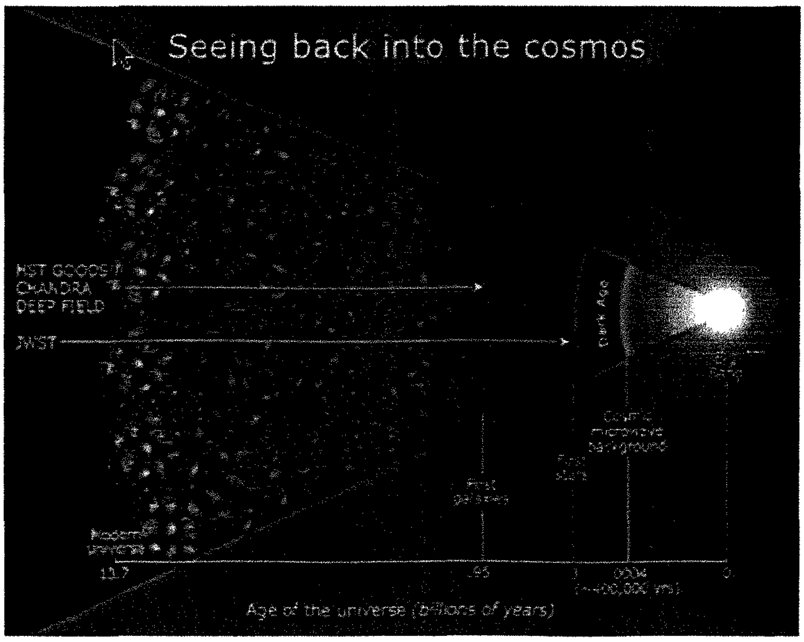
In recent years, Graham said, a number of studies had revealed that the innermost centers of giant elliptical galaxies - the inner 1 percent - had been scoured out or emptied of stars. Astronomers suspect that massive black holes are responsible, gravitationally hurling away any stars that ventured too near and devouring the stars that came in really close.

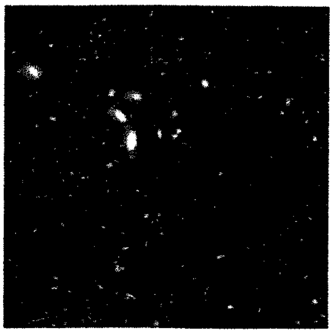
This scouring phenomenon had tended to dim the centers of giant elliptical galaxies, which ran counter to the trend that bigger galaxies tend to have brighter centers. The dimming phenomenon was also one reason astronomers had concluded dwarf and giant galaxies must be different types.

Building on recent revelations showing a strong connection between the mass of the central black holes and the properties of their host galaxies, Graham and his colleagues introduced a new mathematical model that simultaneously describes the distribution of stars in the inner and outer parts of the galaxy.

"It was only after allowing for the modification of the cores by the black holes that we were able to fully unify the dwarf and giant galaxy population," Graham said.

http://www.spaceflightnow.com/news/n0306/21simple/





POVG MEETING - MINUTES

Perth Observatory Volunteer Group Inc

Minutes Of Meeting May 26th
Meeting Commenced at 7.20

Attendance.
T.Dunn. J.Morris. L.Martin.L.Bell. B.Hollibon. J.Alcroft J.Milner. J.Biggs. J.Colletti. M.Zangerer. M.Freeman. E.Cowlishaw. B.Harris. E.Walker. D.Alderson. L.Robinson

Apologies.
T.Beston. F.Bilki. D.Hartley. A.MacNaughtan. R.Taylor. S.Schediwy. D.Emrich. J.Bell. T.Turner.

Minutes of the Previous Meeting. Agreed that they were a true and correct record on the motion of
M.Freeman and L.Martin

Treasurers Report. B.Harris presented an audited report duly signed by Auditor G.Sweeney.

The seat plaques had been paid for and the bank account now has a balance of $118.13. It was agreed that the name of J.Morris Secretary by added to the list of office bearers able to sign cheques.

Chairmans Report. T.Dunn showed the seat plaques he had obtained at a cost of $90.00. J.Morris agreed to fix them to the seats. The funding application had been sent in to the

Regional Development Fund and a response was expected by the end of the month. A letter from C.Bell was tabled thanking the group for their card and best wishes , L.Bell reported that she was halfway through her Chemotherapy treatment and was progressing well. M.Freeman reported on his progress with the proposed trip to the Shoemaker Impact Crater, details would be conveyed to all Members , regarding Dates, Times, and Costs.

T.Dunn asked whether final figures were available regarding numbers attending

Public tours for the past season. J.Biggs stated that preliminary figures were that 5300 had attended, about 600 down on last year.

The Chairman then welcomed 3 new members to the group , J.Coletti. M.Zangerer. and E.Walker.

Other Business.
J.Biggs stated that the trip to New Norcia had roused a lot of interest , final details had still to be finalised , but it was hoped the event would take place around the end of June. He asked whether there were any suggestions for speakers to address the Volunteer group at the monthly meetings.

The Chairman T.Dunn reported that he would be absent from the next meeting as he would be on holiday in the U.K.

There being no further General Business the Meeting closed at 8.15.

'SONGS OF THE STARS'
THE REAL MUSIC OF THE SPHERES

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VENUE: Elizabeth Jolley Lecture Theatre,
Curtin Uni (enter the Uni from the SW side)
DATE: Wednesday 2 July 2003
TIME: 7:30pm
COST: $5 (call Perth Observatory to book tickets)

2003/2004 TRAINING NIGHTS SCHEDULE

2003	2004
May 26	Jan 19
Jun 30	Feb 23
Jul 28	Mar 15
Aug 25	Apr 19
Sep 22	May 17
Oct 20	Jun 14
Nov 24	Jul 12
	Aug 9

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

POVG
Perth Observatory Volunteers Group

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

COMING EVENTS FOR JULY

2nd - 4th - Moon passes Jupiter and Regulus (the brightest star in the constellation Leo The Lion)(evening sky).
3rd - Asteroid 1999 LT7 near-Earth flyby (0.070 AU).
4th - Earth at Aphelion (1.017 AU From Sun).
4th - Henrietta Leavitt's 135th Birthday (1868)
8th - Venus Passes 0.8 Degrees From Saturn
11th - Moon at perigree
14th - Full Moon. Avoid nights around this date for star parties.
14th - Asteroid 1566 Icarus closest approach to Earth (0.978 AU).
17th - Moon Occults Mars
19th - Asteroid (976) Benjamina occults a 5.7 magnitude star (easily visible in binoculars) (evening sky).
Parts of Southern Australia will see this easily visible occultation. For more information, visit http://www.netstevepr.com/Asteroids/special/0719_976.htm.
20th - Asteroid 2000 OL8 near-Earth flyby (0.055 AU).
23rd - Moon at apogee
26th - Mercury and Jupiter conjunction. Look low on the North Western horizon for two bright 'stars' close together (evening sky).
26th - Mercury Passes 0.3 Degrees From Jupiter
26th - Asteroid 2000 PH5 near-Earth flyby (0.012 AU).
29th - South Delta-Aquarids Meteor Shower Peak.
30th - Mercury and Regulus conjunction (evening sky).
31st & August 1st - Moon passes Jupiter, Mercury and Regulus (the brightest star in the constellation Leo The Lion). Low on the Western horizon but worth a look (evening sky).
31st - Mars Stationary

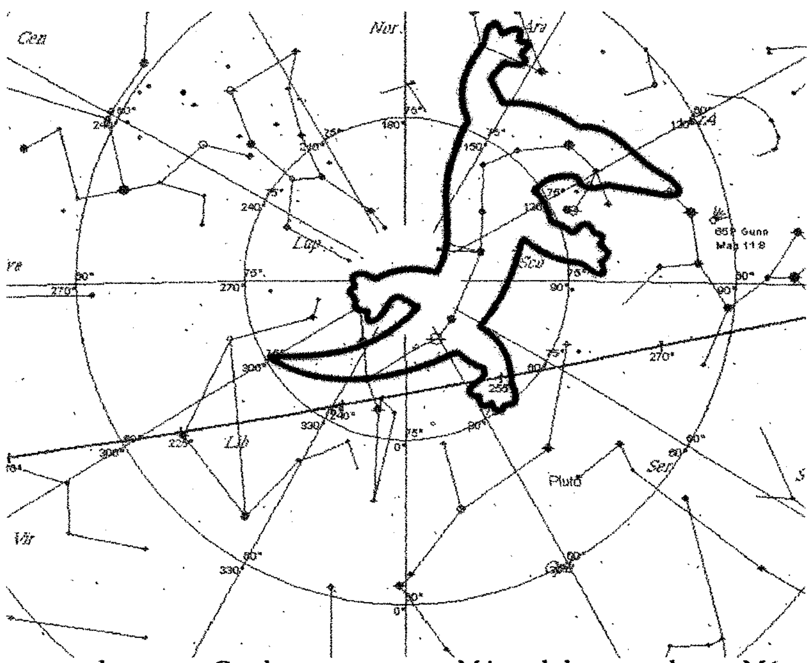
http://www.ozskywatch.com/amaz/space/skyevent/2003/summary.html#anchor488707
http://www.jpl.nasa.gov/calendar/#0307

ABORIGINAL CONSTELLATION OF THE MONTH - JULY: INGALPIR – THE CROCODILE

For the most part, when we view a constellation we can only wonder at what mind-altering drugs that constellation's authors were using when they invented it. However, the constellation that we know as Scorpius is a notable exception to the rule. It really does look like a scorpion, complete with head and stinger.

Aboriginal sky watchers knew Scorpius as Ingalpir the crocodile, and once again it actually resembles its namesake. Members of Australia's northern tribes feared crocodiles and have created many legends about those who have no respect for these dangerous animals. Some groups even saw three men within the crocodile, one playing the didgeridoo and the other two singing and clapping sticks.

For others, Ingalpir's appearance in early morning December skies meant that Malay traders would arrive to exchange knives and axes for sea cucumber, which they would trade to the Chinese.



Astronomically, Scorpius is a very rich region. Its brightest star was known to Greek astronomers as Antares, which means 'Rival of Mars', because of its redness. In Greek mythology, Scorpius was the scorpion that killed Orion. To the Romans it was Cor Scorpionis, which means 'heart of the scorpion'. For Aboriginal sky watchers, it was known as Djuit. The globular cluster M4, and the open clusters M6 (the Butterfly cluster) and M7, also lie within the scorpion's boundary. And of course, when we look in the direction of Scorpius and Sagittarius, we are looking towards the centre of our own Milky Way galaxy.

Frank Bilki

PERTH OBSERVATORY
VOLUNTEERS GROUP INC.
MEMBER LIST

JEFF ALCROFT
DICK ALDERSON
JEANNE BELL
TREVOR BEARDSMORE
LYALL BELL
FRANK BILKI
TONY BESTON
RIC BOELEN
EVE COWLISHAW
GIUSEPPE COLETTI
PETER CRAKE,
TREVOR DUNN
DAVID EMICH
MARCEL FORTSCH
MIKE FREEMAN
LYNDA FREWER
BEVAN HARRIS
DON HARTLEY
MARK HASLAM
JAMES HEALY
BERT HOLLEBON
KAREN KOTZE
ERIN LALOR
VIC LEVIS
ROB LONEY
ANDREW MACNAUGHTAN
LEN MARTIN
JACQUIE MILNER
JOHN MORRIS
KYLIE RALPH
LLOYD ROBINSON
SASCHA SCHEDIWY
VAL SEMMLER
VERA SMITH
ROBERT TAYLOR,
PATRICIA TURNER
ELAINE WALKER
SANDRA WALKER
MATTHEW ZENGERER

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

Trevor Dunn	POVG Inc, Chairperson
Karen Koltze	POVG Inc, Vice Chair
Bob Taylor	POVG Inc, Secretary
Bevan Harris	POVG Inc, Treasurer and newsgroup

moderator (contact bevan on ngc2070@bigpond.com)

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

HAPPY BIRTHDAY VOLLIES & STAFF FOR JUNE

BEVAN HARRIS	JOHN MORRIS	ROBERT TAYLOR,
KAREN KOTZE	JOHN PEARCE	DAVID TIGGERDINE
VIC LEVIS	LLOYD ROBINSON	
ROB LONEY	VERA SMITH	

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Mon. Not. R. Astron. Soc. **340**, 1031–1038 (2003)

Amplitude and frequency variability of the pulsating DB white dwarf stars KUV 05134+2605 and PG 1654+160 observed with the Whole Earth Telescope

G. Handler,[1,2★] D. O'Donoghue,[1] M. Müller,[3] J.-E. Solheim,[4] J. M. Gonzalez-Perez,[4] F. Johannessen,[4] M. Paparo,[5] B. Szeidl,[5] G. Viraghalmy,[5] R. Silvotti,[6] G. Vauclair,[7] N. Dolez,[7] E. Pallier,[7] M. Chevreton,[8] D. W. Kurtz,[7,9] G. E. Bromage,[9] M. S. Cunha,[10,11] R. Østensen,[12] L. Fraga,[13] A. Kanaan,[13] A. Amorim,[13] O. Giovannini,[14] S. O. Kepler,[15] A. F. M. da Costa,[15] R. F. Anderson,[16] M. A. Wood,[17] N. Silvestri,[17] E. W. Klumpe,[18] R. F. Carlton,[18] R. H. Miller,[19] J. P. McFarland,[19] A. D. Grauer,[20] S. D. Kawaler,[21] R. L. Riddle,[21] M. D. Reed,[22] R. E. Nather,[23] D. E. Winget,[23] J. A. Hill,[23] T. S. Metcalfe,[23,24] A. S. Mukadam,[23] M. Kilic,[23] T. K. Watson,[25] S. J. Kleinman,[26] A. Nitta,[26] J. A. Guzik,[27] P. A. Bradley,[27] K. Sekiguchi,[28] D. J. Sullivan,[29] T. Sullivan,[29] R. R. Shobbrook,[30,31] X. Jiang,[32] P. V. Birch,[33] B. N. Ashoka,[34] S. Seetha,[34] V. Girish,[34] S. Joshi,[35] T. N. Dorokhova,[36] N. I. Dorokhov,[36] M. C. Akan,[37] E. G. Meištas,[38] R. Janulis,[38] R. Kalytis,[39] D. Ališauskas,[39] S. K. Anguma,[40] P. C. Kalebwe,[41] P. Moskalik,[42] W. Ogloza,[42,43] G. Stachowski,[42] G. Pajdosz[43] and S. Zola[43,44]

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[2] *Present address: Institut für Astronomie, Universität Wien, Türkenschanzstraße 17, A-1180 Wien, Austria*
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[4] *Institutt for Matematiske Realfag, Nordlysobservatoriet, Universitet i Tromsø 9000 Tromsø, Norway*
[5] *Konkoly Observatory, Box 67, H-1525 Budapest XII, Hungary*
[6] *Osservatorio Astronomico di Capodimonte, via Moiariello 16, I-80131 Napoli, Italy*
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ABSTRACT

We have acquired new time series photometry of the two pulsating DB white dwarf stars KUV 05134+2605 and PG 1654+160 with the Whole Earth Telescope. Additional single-site photometry is also presented. We use all these data plus all available archival measurements to study the temporal behaviour of the pulsational amplitudes and frequencies of these stars for the first time.

We demonstrate that both KUV 05134+2605 and PG 1654+160 pulsate in many modes, the amplitudes of which are variable in time; some frequency variability of PG 1654+160 is also indicated. Beating of multiple pulsation modes cannot explain our observations; the amplitude variability must therefore be intrinsic. We cannot find stable modes to be used for determinations of the evolutionary period changes of the stars. Some of the modes of PG 1654+160 appear at the same periods whenever detected. The mean spacing of these periods ($\approx$40 s) suggests that they are probably caused by non-radial gravity-mode pulsations of spherical degree $\ell = 1$. If so, PG 1654+160 has a mass around $0.6\,M_{\odot}$.

The time-scales of the amplitude variability of both stars (down to two weeks) are consistent with theoretical predictions of resonant mode coupling, a conclusion which might however be affected by the temporal distribution of our data.

Key words: stars: individual: KUV 05134+2605 – stars: individual: PG 1654+160 – stars: oscillations – stars: variables: other.

1 INTRODUCTION

In recent times it has become clear that amplitude and frequency variations are common amongst pulsating stars. Various mechanisms for their explanation have been proposed. For example, resonant mode interaction (Moskalik 1985) is consistent with observations of this phenomenon in δ Scuti stars (e.g. Handler et al. 1998, 2000), whereas frequency changes of rapidly oscillating Ap stars may be attributed to variations in the magnetic field (Kurtz et al. 1994, 1997).

Time-resolved photometric observations of pulsating (pre-)white dwarf stars revealed that they are no exception in this respect. This bears a potentially enormous astrophysical reward: although these stars may only make part of their pulsation spectra observable to us at a given time, they may reveal their complete mode spectrum when observed persistently. Kleinman et al. (1998), Bond et al. (1996) and Vauclair et al. (2002) took advantage of this possibility and could then make seismic analyses for a pulsating DA white dwarf (G29-38) and two pulsating central stars of planetary nebulae (NGC 1501, RXJ 2117+3412). Without their amplitude variability, these stars would still be poorly understood.

Published reports of amplitude and frequency variations are still sparse for the helium-atmosphere pulsating DB white dwarf stars (DBVs, see Bradley 1995, for a review), but so are their time-series photometric observations, mainly due to their faintness (most DBVs are around 16$^{\rm th}$ magnitude). The glaring ($B = 13.5$) exception is the prototype DBV GD 358 for which a plethora of measurements, including three Whole Earth Telescope (WET, Nather et al. 1990) runs, is available. Although the mode amplitudes of GD 358 vary, the associated pulsation frequencies seem reasonably stable (Kepler et al. 2003). Very recently, some amplitude and frequency variations have also been reported for the DBVs CBS 114 and PG 1456+103 (Handler, Metcalfe & Wood 2002).

We have started a systematic observing program to obtain reliable frequency analyses of the mode spectra of all pulsating DB white dwarfs. Our measurements consist of extensive single-site observations, which can suffice for very simply-behaved objects (Handler 2001), or low-priority WET observations (this paper), or even full worldwide multisite campaigns.

2 OBSERVATIONS AND REDUCTIONS

The pulsating DB white dwarf stars KUV 05134+2605 and PG 1654+160 were chosen as secondary target stars for the WET runs Xcov20 and Xcov21 during 2000 November and 2001 April,

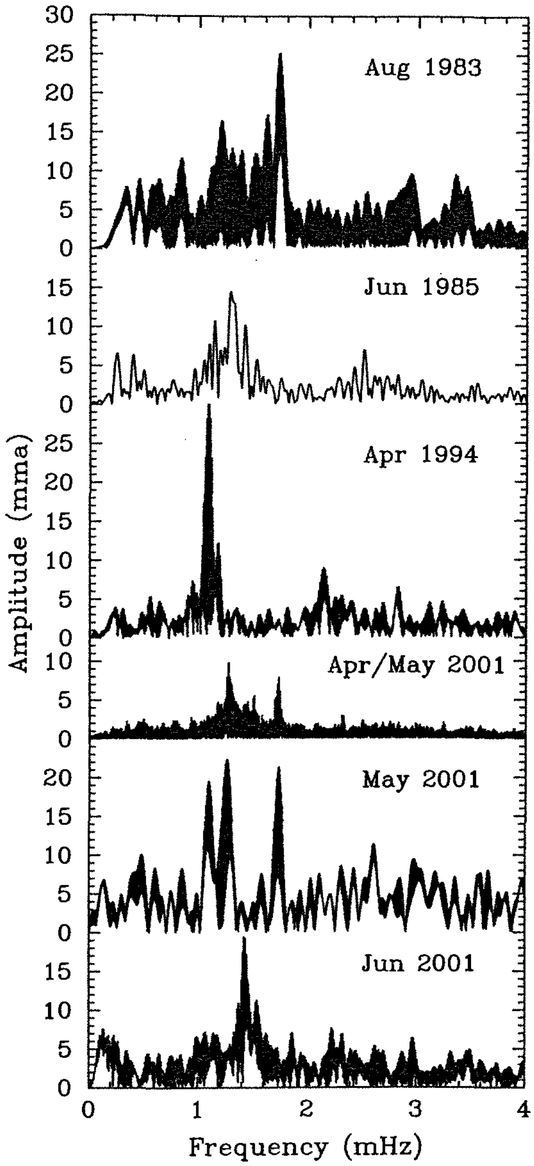

Figure 6. Amplitude spectra of all available measurements of PG 1654+160. This star also shows conspicuous amplitude variability.

800 s) in the light curves of PG 1654+160 appear very consistently in the same regions, whereas the longer periods do not show that much regularity. However, the errors in the determination of those periods are also larger. Finally, the previously mentioned shorter-period signals seem to have an approximately equidistant spacing of about 40 s, and again our data show no sufficiently stable modes to estimate the evolutionary period change rate.

4 DISCUSSION

We have shown that the amplitude spectra of both KUV 05134+2605 and PG 1654+160 are variable in time. Whereas we cannot find an underlying pattern in the periods of KUV 05134+2605, the roughly equidistant spacings within the shorter periods of PG 1654+160 suggests the presence of a number of radial overtones of g-modes. The size of this average period separation ($\approx$40 s) is consistent with the expected mean period spacing

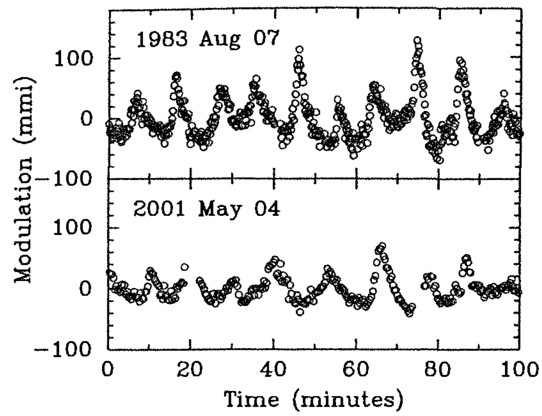

Figure 7. Upper panel: the discovery light curve of PG 1654+160. Lower panel: one of the light curves acquired during the WET run on the star. Again, the pulsational time-scales and amplitudes changed considerably.

of a normal-mass ($\approx$0.6 $M_\odot$) DBV white dwarf pulsating in $\ell = 1$ modes (see, e.g. Bradley, Winget & Wood 1993).

A comparison of the individual mode periods of the known $\ell = 1$ pulsator GD 358 (Winget et al. 1994; Vuille et al. 2000) and those of another DBV, CBS 114 (Handler et al. 2002), with that of PG 1654+160 also supports this interpretation. However, the number of available observed modes of PG 1654+160 is insufficient for seismic model calculations, and the uncertainties of their periods are too large.

What may be the cause of the amplitude (and possibly also frequency) variability in the two stars? As neither has been reported to be magnetic in the literature, interaction between the different pulsation modes remains the most promising hypothesis for an explanation.

In this case, the time-scale of the amplitude variability is expected to be of the order of the inverse growth rates of the affected modes. Growth rates are not very well known for pulsating white dwarfs, but it is clear that longer-period modes have larger growth rates than shorter-period ones. Detailed growth-rate calculations (Dolez & Vauclair 1981) imply that amplitude variability may occur on time-scales down to about one week.

These theoretical predictions are consistent with our observations, at least as far as we can tell. The longer-period modes of PG 1654+160 indeed seem to vary more rapidly in amplitude than the ones at shorter period [it is interesting to note that Kepler et al. (2003) made the same observation for GD 358], as implied by our attempts to trace these variations. The time-scale of the amplitude variability of both stars also appears to be of the expected order of magnitude. However, we must admit that the temporal distribution of our data is such that we can only detect variations on just these time-scales. Hence, the agreement we find can at best be regarded as qualitative.

5 SUMMARY AND CONCLUSIONS

We have carried out new Whole Earth Telescope measurements of the two pulsating DB white dwarf stars KUV 05134+2605 and PG 1654+160 which were supplemented by single-site data. We also re-analysed all available archival measurements of the two stars.

We showed, for the first time, that both have rich pulsational mode spectra, and that the pulsation amplitudes of both stars are highly

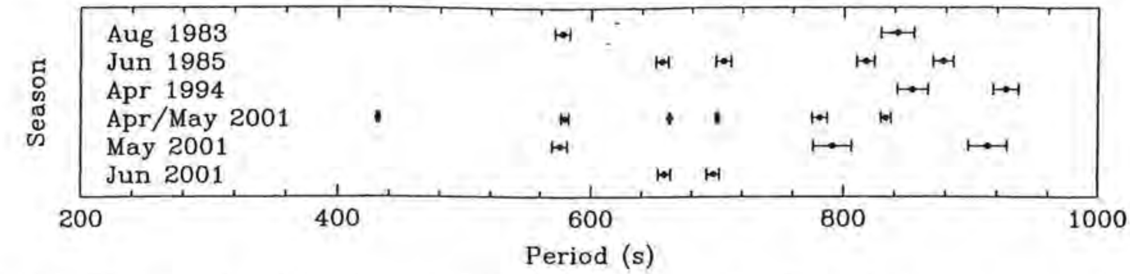

Figure 8. The variability periods of PG 1654+160 as listed in Table 4. Signals with periods below 800 s occur at the same frequencies whenever detected, and they are spaced by integer multiples of about 40 s.

variable in time; PG 1654+160 may show some frequency variability in addition. Beating of multiple pulsation modes cannot explain all our observations, as the observed amplitude and frequency variability is too complex for such an interpretation; hence it must be intrinsic. The pronounced amplitude variations made it impossible to find stable modes to determine the evolutionary period change rates of the two stars.

Whereas there seems no systematic pattern in the periods of KUV 05134+2605 we measured, some of the modes of PG 1654+160 appear at the same periods whenever detected. The spacing of these periods, around 40 s, suggests that they are probably caused by non-radial gravity-mode pulsations of spherical degree $\ell = 1$ in a normal-mass DBV white dwarf.

The amplitude variabilities of both stars could be followed by means of the pre- and post-WET observations that were therefore essential for this work. Their time-scales are consistent with theoretical predictions of resonant mode coupling. This conclusion is however weakened by the temporal distribution of our data, which favour the detection of just those variability time-scales.

Before a more detailed investigation of the amplitude variations of these two stars can be performed (e.g. to guide theoretical work in this direction, Buchler, Goupil & Serre 1995), mode identifications and an improved sampling of the temporal behaviour of the pulsations through continued single-site measurements are desirable. Given the qualitative similarity of PG 1654 and the 'typical' DBV GD 358, we expect that the same nonlinear mode coupling and amplitude modulation mechanisms are at work in both stars. Having very rich mode spectra, both KUV 05134+2605 and PG 1654+160 are also attractive targets for future extensive multisite campaigns.

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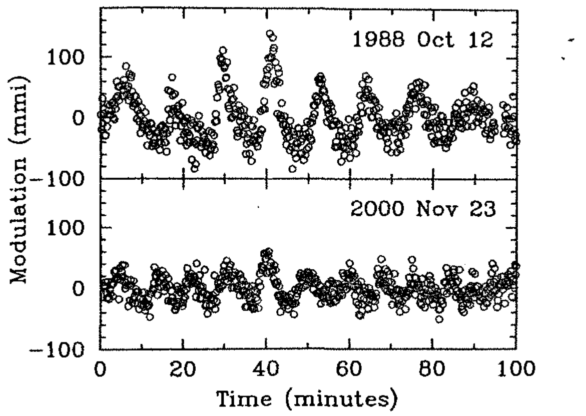


Figure 2. Upper panel: the discovery light curve of KUV 05134+2605. Lower panel: one of the light curves acquired during the WET run on the star. Note the change in the pulsational time-scales and amplitudes.

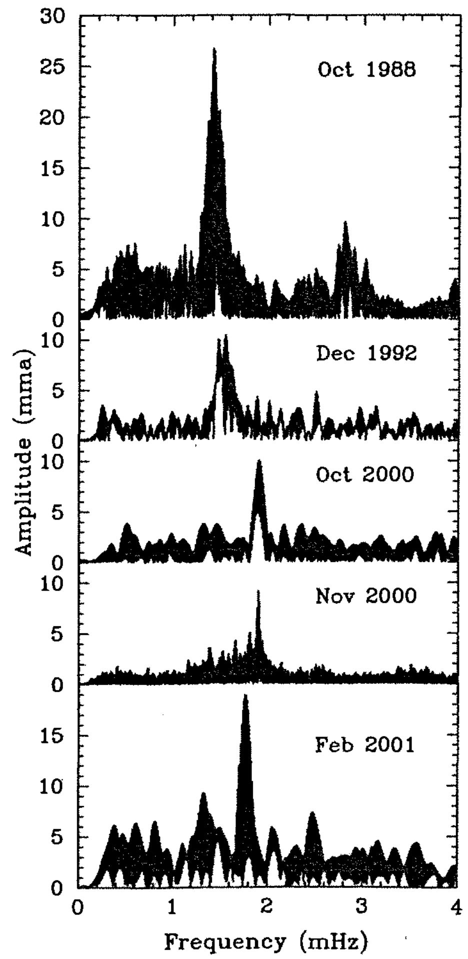


Figure 3. Amplitude spectra of all available measurements of KUV 05134+2605. The frequencies and amplitudes of the dominant signals are different in almost every data set.

on time-scales as short as 6 weeks. We cannot make any statement about frequency/phase variability as our data sets are too small to distinguish this hypothesis from the effects of beating between several signals.

We can attempt to construct the complete mode spectrum of the star by combining the results of the different observing seasons.

Table 3. Dominant signals in the light curves of KUV 05134+2605 in our data. The error estimates in the periods include alias ambiguities, and amplitudes are listed for completeness.

Month/Year	Period (s)	Amplitude (mma)
Oct 1988	707 ± 6	25
	665 ± 7	16
	777 ± 8	10
Dec 1992	645 ± 9	10
	678 ± 11	9
Oct 2000	525 ± 7	9
Nov 2000	526 ± 3	9
	556 ± 4	4
	600 ± 4	4
	716 ± 5	3
Feb 2001	567 ± 8	18
	757 ± 14	8

Of course, all the data sets are affected by aliasing and no definite periods can be determined, but approximate periods in the different regions of power in the Fourier spectra that are separated by more than the width of the envelope of the corresponding spectral window, can be estimated. We summarize these results, omitting possible combination frequencies, in Table 3. The amplitudes in this table must be taken with some caution, as they could be affected by insufficient frequency resolution in some of the data sets.

As already noted, there is no correspondence between the period of the dominant modes in each of the subsets of data except for the two closest in time (2000 October/November). It almost appears that we looked at a different star every time KUV 05134+2605 was observed!

In any case, we tried to find the signatures of non-radial gravity (g)-mode pulsations from Table 3, also with the help of Fig. 4, where we plot the detected periods over the different observing seasons. However, equally spaced periods suggestive of the presence of a number of radial overtones of the same ℓ or equally spaced frequencies that might be due to rotational m-mode splitting were not detected.

We can therefore summarize the frequency analysis of KUV 05134+2605 as follows: it has a very rich mode spectrum and its pulsation amplitudes are highly variable. We cannot find a stable pulsational signal which would allow us to estimate an evolutionary period change. Only a dedicated multisite campaign would help to understand this star.

3.2 PG 1654+160

We again start the frequency analysis with the WET measurements. The spectral window and amplitude spectrum of these data are shown in Fig. 5. Although the amplitude spectrum does not appear very complicated, attempts to determine the underlying variations by prewhitening result in a large number of signals that seem to be present.

However, assuming that we deal with normal-mode pulsations of the star, the number of signals becomes unrealistically large, and some of the frequencies found that way are too closely spaced to be resolved within our data set. All this suggests that the amplitude spectrum of PG 1654+160 was not stable throughout the observations.

Consequently, we attempted to follow the suspected amplitude and frequency variability throughout the data set with various

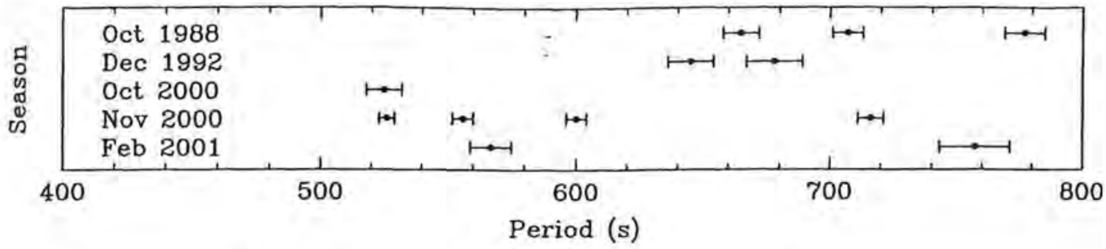


Figure 4. The variability periods of KUV 05134+2605 as listed in Table 3.

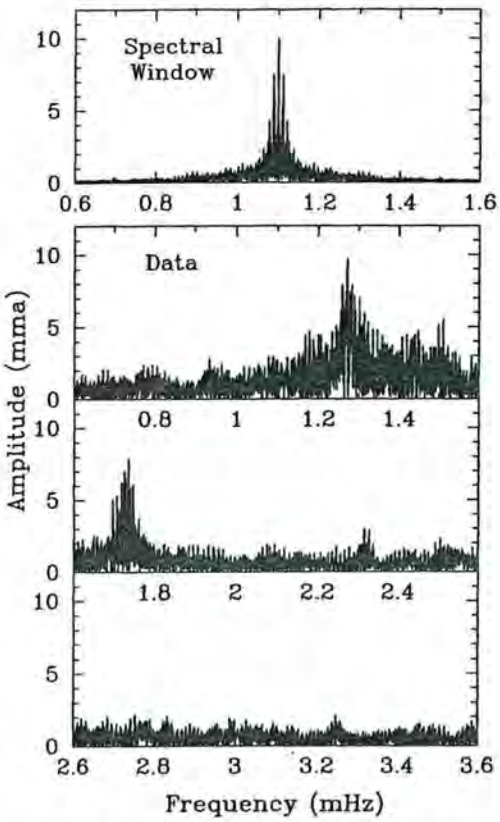


Figure 5. Spectral window and amplitude spectra of the WET measurements of PG 1654+160.

methods but again had to realize that our temporal coverage is insufficient for a detailed analysis. Some results can however be obtained.

(i) The longer period pulsations ($P \gtrsim 700$ s) show a larger degree of instability.

(ii) The amplitude spectrum was more stable during the second part of the run (beginning with April 25).

(iii) Amplitude variability alone is insufficient to account for the observed variations; the pulsation frequencies also appear somewhat variable.

(iv) The periods of the strongest signals can be determined, albeit with large errors due to the instability and aliasing.

The periods we could determine are listed in Table 4, together with the results from the other data sets to which we now turn.

In the same fashion as in the previous section, we computed amplitude spectra of all our data sets over the years. We show them in Fig. 6 which demonstrates that the pulsational behaviour of PG 1654+160 is also highly variable in time; a comparison of light curves is shown in Fig. 7. The time-scales of the amplitude variations of PG 1654+160 can be as short as two weeks: the strong 913-s signal in the May 2001 data was absent in the previous WET data.

Table 4. Dominant signals in our light curves of PG 1654+160. The error estimates in the periods include alias ambiguities, and amplitudes are listed for completeness.

Month/Year	Period (s)	Amplitude (mma)
Aug 1983	577 ± 6	24
	842 ± 13	15
June 1985	777:	14
	756:	11
	705 ± 6	10
	878 ± 8	10
	817 ± 7	8
	656 ± 5	6
Apr 1994	927 ± 10	31
	854 ± 16	12
Apr/May 2001 (WET)	781 ± 6	10
	579 ± 3	8
	662.0 ± 0.5	5
	700 ± 1	4
	833 ± 4	4
	431 ± 1	3
May 2001	791 ± 15	21
	575 ± 6	20
	913 ± 15	19
June 2001	697 ± 5	19
	658 ± 5	12

We determined the dominant periods in the different data sets, and summarize them in Table 4. Again, the amplitudes may be affected by resolution problems, and possible combination frequencies were excluded. In addition, there is good evidence for more signals being present in several of the data sets, but it is not possible to determine their periods and amplitudes reliably.

Some comments are necessary: the two strongest modes in the single-night data set from 1985 June are not resolved, which is why we cannot determine error estimates for their periods and thus disregard them for the following analysis. The errors on the other frequencies in this data set were assumed to be $1/4T$, where T is the length of the run. For the other data sets, the errors on the periods include some possible alias ambiguities. In the 1994 April data, the $2f$ harmonic of the dominant periodicity is also present. We therefore used the residualgram method (as described before) with $M = 2$ to obtain a more reliable determination of this period before searching for more signals.

It is interesting to note that some periodicities in Table 4 occur in more than one data set. We have displayed these results graphically in Fig. 8, where we again show the detected periods over the different observing seasons. We note that the shorter periods ($P <$

Table 1. Time-series photometry of KUV 05134+2605. The first part of the table contains the WET measurements, the second part lists additional single-site observations, and the third part contains the available discovery data (Grauer et al. 1989). Runs marked with asterisks were obtained with a CCD.

Run name	Obs./Tel.	Date (UT)	Start (UT)	Length (h)
asm-0080	McD 2.1m	2000 Nov 20	11:32:40	0.90
asm-0082	McD 2.1 m	2000 Nov 21	10:35:30	1.78
joy-003	McD 2.1 m	2000 Nov 23	10:20:00	2.16
joy-013	McD 2.1 m	2000 Nov 26	08:52:16	3.55
joy-017	McD 2.1 m	2000 Nov 27	10:08:40	2.38
joy-021	McD 2.1 m	2000 Nov 28	07:16:20	5.10
joy-026	McD 2.1 m	2000 Nov 29	09:48:50	2.77
sara-0054*	SARA 0.9 m	2000 Nov 30	04:53:00	8.49
joy-029	McD 2.1 m	2000 Nov 30	09:51:20	2.50
joy-032	McD 2.1 m	2000 Dec 01	09:10:00	3.44
sara-0055*	SARA 0.9 m	2000 Dec 03	05:18:20	8.01
sara-0057*	SARA 0.9 m	2000 Dec 05	03:21:00	5.47
tsm-0088	McD 2.1 m	2000 Dec 05	09:46:00	2.67
KU1229OH	OHP 1.9 m	1992 Dec 29	18:23:00	5.00
KU1230OH	OHP 1.9 m	1992 Dec 30	17:50:00	4.50
gh-0484*	SAAO 1.0 m	2000 Oct 04	00:45:26	2.55
gh-0486*	SAAO 1.0 m	2000 Oct 05	00:42:07	2.02
gh-0488*	SAAO 1.0 m	2000 Oct 06	00:36:43	2.76
gh-0492*	SAAO 1.0 m	2000 Oct 09	00:15:49	3.03
gh-0493*	SAAO 0.75 m	2001 Jan 30	19:01:40	2.40
gh-0496*	SAAO 0.75 m	2001 Jan 31	18:57:10	2.40
gh-0499*	SAAO 0.75 m	2001 Feb 01	18:40:15	2.62
adg-0076	MtB 1.5 m	1988 Oct 12	09:37:20	2.43
adg-0077	MtB 1.5 m	1988 Oct 13	08:23:10	1.67
adg-0080	MtB 1.5 m	1988 Oct 14	06:52:30	1.10
adg-0081	MtB 1.5 m	1988 Oct 14	10:19:20	1.86
adg-0082	MtB 1.5 m	1988 Oct 16	09:45:10	2.48
adg-0084	MtB 1.5 m	1988 Oct 18	07:26:00	1.98
Total WET				49.22
Grand total				88.02

Observatory codes: McD = McDonald Observatory (USA), SARA = Southeastern Association for Research in Astronomy Observatory (USA), OHP = Observatoire de Haute-Provence (France), SAAO = South African Astronomical Observatory, MtB = Steward Observatory (Mt. Bigelow site, USA).

respectively. Such secondary programme stars are observed by the network if the primary target is not observable or if two telescopes are on line and the larger one already measures the primary or if the observing method at a certain site is not suitable for the primary (e.g. CCDs are not proper instruments for very bright stars). Although the temporal coverage of the variations of a secondary target is usually considerably poorer than that of the primary, the resulting data sets are often quite valuable (see Handler et al. 1997 for an example).

In addition to the WET measurements, we acquired single-site observations of KUV 05134+2605 and PG 1654+160 before and/or after the main data stream. In an effort to understand these two stars to the limits currently possible, we also (re)analysed all available published and unpublished measurements. The time-series photometric data at our disposal are listed in Tables 1 and 2.

Most of the observations consisted of multichannel high-speed photoelectric photometry with 10-s integrations (see Kleinman, Nather & Philips 1996, for more information). Channel 1 measured the programme star, channel 2 measured a local comparison star, and channel 3 simultaneously recorded sky background. If no third channel was available, the measurements were irregularly interrupted to measure sky. Data reduction was performed with a standard procedure, as e.g. described by Handler et al. (1997).

Table 2. Time-series photometry of PG 1654+160. The first part of the table contains the WET measurements, the second part lists additional single-site observations, and the third part reports the available discovery data (Winget et al. 1984). Runs marked with asterisks were obtained with a CCD.

Run name	Obs./Tel.	Date (UT)	Start (UT)	Length (h)
sara-0081*	SARA 0.9 m	2001 Apr 17	10:53:30	1.36
luc02a	LNA 1.6 m	2001 Apr 20	04:36:10	0.36
luc03a	LNA 1.6 m	2001 Apr 20	05:51:10	1.13
luap21c	LNA 1.6 m	2001 Apr 21	03:12:00	2.48
luap21d	LNA 1.6 m	2001 Apr 21	05:43:40	2.32
sara-0083*	SARA 0.9 m	2001 Apr 21	06:52:25	5.33
mdr160	CTIO 1.5 m	2001 Apr 21	08:38:50	1.56
luap22c	LNA 1.6 m	2001 Apr 22	07:10:40	1.11
mdr163	CTIO 1.5 m	2001 Apr 22	09:05:20	1.05
luap23b	LNA 1.6 m	2001 Apr 23	06:42:00	1.75
sara-0085*	SARA 0.9 m	2001 Apr 23	09:48:50	2.26
luap24c	LNA 1.6 m	2001 Apr 24	02:58:00	1.35
luap24d	LNA 1.6 m	2001 Apr 24	04:29:00	0.89
mdr166	CTIO 1.5 m	2001 Apr 24	07:50:30	2.33
luap25b	LNA 1.6 m	2001 Apr 25	03:27:00	2.13
mdr169	CTIO 1.5 m	2001 Apr 25	06:37:00	3.45
gh-0508	SAAO 1.9 m	2001 Apr 26	02:06:40	1.94
luap26b	LNA 1.6 m	2001 Apr 26	03:01:00	5.40
NOTkd25b*	NOT 2.6 m	2001 Apr 26	03:29:00	2.46
mdr172	CTIO 1.5 m	2001 Apr 26	09:03:40	1.14
gh-0509	SAAO 1.9 m	2001 Apr 27	00:59:40	2.83
NOTkd26c*	NOT 2.6 m	2001 Apr 27	01:17:20	4.49
luap27b	LNA 1.6 m	2001 Apr 27	03:12:00	3.49
luap27c	LNA 1.6 m	2001 Apr 27	06:52:00	1.46
mdr175	CTIO 1.5 m	2001 Apr 27	09:05:20	1.06
sara-0092*	SARA 0.9 m	2001 Apr 28	06:22:50	5.73
mdr178	CTIO 1.5 m	2001 Apr 28	07:51:40	2.30
sara-0095*	SARA 0.9 m	2001 Apr 29	06:05:25	5.96
gh-0517	SAAO 1.9 m	2001 May 01	02:07:30	1.90
NOTkd30c*	NOT 2.6 m	2001 May 01	03:49:40	1.84
NOTke02a*	NOT 2.6 m	2001 May 02	23:08:50	5.11
NOTke03d*	NOT 2.6 m	2001 May 04	02:22:42	3.33
r3076	McD 2.1 m	1985 Jun 21	03:39:00	6.61
sjk-0317	McD 0.8 m	1994 Apr 06	06:40:30	5.14
sjk-0319	McD 0.8 m	1994 Apr 07	06:28:00	5.42
pi-001*	PO 1.0 m	2001 May 14	21:27:53	4.59
pi-002*	PO 1.0 m	2001 May 16	22:21:34	3.61
pi-003*	PO 1.0 m	2001 Jun 25	19:49:39	1.89
pi-004*	PO 1.0 m	2001 Jun 26	20:47:06	4.01
pi-005*	PO 1.0 m	2001 Jun 27	20:51:02	2.50
r2817	McD 2.1 m	1983 Aug 02	05:32:46	1.43
r2819	McD 2.1 m	1983 Aug 04	03:27:13	0.47
r2822	McD 2.1 m	1983 Aug 07	03:16:00	3.49
Total WET				81.30
Grand total				120.46

Observatories: SARA = Southeastern Association for Research in Astronomy Observatory (USA), LNA = Osservatório do Pico dos Dias (Brazil), CTIO = Cerro Tololo Interamerican Observatory (Chile), SAAO = South African Astronomical Observatory, NOT = Nordic Optical Telescope (Tenerife), McD = McDonald Observatory (USA), PO = Piszkestetö Observatory (Hungary).

Our CCD measurements were acquired with a number of different photometers – which we do not describe in detail here. The observations were optimized to acquire at least two local comparison stars in the same field as the target by minimizing the readout time, ensuring a duty cycle as high as possible. In this way, consecutive data points were obtained in 10–30 s intervals, depending on the instrument.

CCD data reduction comprised correction for bias, dark counts and flat-field. Photometric measurements on these reduced frames were made with the programs MOMF (Kjeldsen & Frandsen 1992) or RTP (Østensen 2000), and differential light curves were created. No variability of any star other than the targets in the different CCD fields was found, and the comparison star ensemble resulting in the lowest scatter in the target star light curves was chosen.

At this point it should be noted that PG 1654+160 has a companion star (Zuckerman & Becklin 1992) at a separation of about 4″ distance that may affect our measurements. Fortunately for us, this companion is very red. Consequently, we used red-cutoff filters, e.g. a Schott BG 39 glass, which suppressed the companion's contribution sufficiently (it then was ~2 mag fainter than the target), but did not waste too many photons of the target star. This also means that the companion's flux did not affect the amplitudes of the photoelectrically measured target star light curves significantly, as all our photomultipliers are blue-sensitive.

Finally, the times of measurement were transformed to Barycentric Julian Ephemeris Date (BJED); the barycentric correction was applied point by point. Finally, some overlapping portions of the combined light curves were merged, and the reduced time series were subjected to frequency analyses.

3 FREQUENCY ANALYSIS

Our frequency analyses were mainly performed with the program PERIOD 98 (Sperl 1998). This package applies single-frequency power spectrum analysis and simultaneous multifrequency sine-wave fitting. It also includes advanced options, such as the calculation of optimal light-curve fits for multiperiodic signals including harmonic, combination, and equally spaced frequencies, which are often found in the analysis of the light curves of pulsating white dwarf stars.

In one case to be indicated later, this method was supplemented by a residualgram analysis (Martinez & Koen 1994), which is based on a least-squares fit of a sine wave with M harmonics. One advantage of this method is that alias ambiguities can be evaluated more reliably by the simultaneous inclusion of the information in the Fourier harmonics.

3.1 KUV 05134+2605

We first analysed the WET measurements of KUV 05134+2605 with PERIOD 98. We computed the spectral window of the data (calculated as the Fourier Transform of a noise-free sinusoid with a frequency of 1.902 mHz and an amplitude of 9.7 milli-modulation amplitudes[1] (mma)) followed by the amplitude spectrum itself. The results are shown in the upper two panels of Fig. 1. As the WET measurements were only acquired from North American observatories (a result from the star having second priority), the window function is poor.

[1] One milli-modulation amplitude is the Fourier amplitude of a signal with a fractional intensity variation of 0.1 per cent; it is a standard unit for WET data analysis.

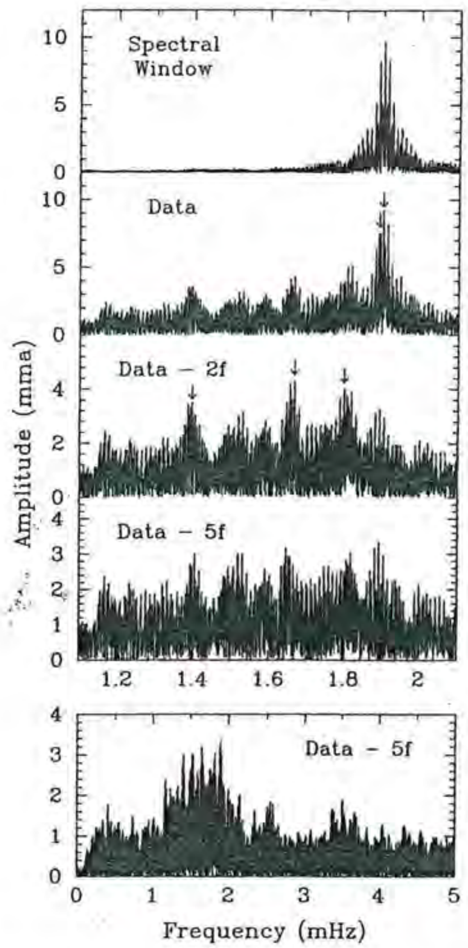


Figure 1. Spectral window and amplitude spectra of the WET measurements of KUV 05134+2605. Some trial prewhitening of the signals indicated with arrows to demonstrate the richness of the frequency spectrum is shown in consecutive panels. Due to the poor spectral window, no frequency can be determined with certainty, but many signals are definitely present in the light curves, as best seen in the lowest panel which shows an extended frequency range.

Still, we show some prewhitening steps in consecutive panels in Fig. 1. This has been done to indicate the main regions in which pulsational signals are present, but definite periods cannot be determined. In any case, it is suggested that KUV 05134+2605 has a rich pulsation spectrum.

This is not the only interesting feature of the pulsations of the star: in the discovery paper (Grauer et al. 1989) it was found to be of much higher amplitude and longer period compared to its pulsational state during the WET run. The star has changed from showing dominant pulsations with time-scales of 710 s and peak-to-peak amplitudes up to 0.2 mag to less than 0.1 mag and a dominant 530-s time-scale (Fig. 2).

We have therefore calculated amplitude spectra of all the available data (Fig. 3). Interestingly, the amplitude spectrum of the star was different every time it was observed. Besides the data discussed before, the measurements from 1992 show a dominant variability time-scale of around 650 s, and the 2001 February data have a prevailing time-scale of 570 s. Only the light curves from October 2000 appear similar to those acquired by the WET some 6 weeks later, but this actually only applies to the signal of highest amplitude. We conclude that KUV 05134+2605 shows notable amplitude variability

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

AUGUST 2003

APPROACHING MARS

Earth and Mars are converging for a close encounter in August. The red planet is already an appealing target for sky watchers.

Count slowly: one one-thousand, two one-thousand, three one-thousand.... You just got about 30 km closer to the planet Mars.

Earth and Mars are rapidly converging. On August 27, 2003--the date of closest approach--the two worlds will be 56 million km apart. That's a long way by Earth standards, but only a short distance on the scale of the solar system. NASA, the European Space Agency and Japan are all sending spacecraft to Mars this year. It's a good time to go.

Between now and August, Mars will brighten until it "blazes forth against the dark background of space with a splendor that outshines Sirius and rivals the giant Jupiter himself." Astronomer Percival Lowell, who famously mapped the canals of Mars, wrote those words to describe the planet during a similar close encounter in the 19th century.

Already Mars is eye-catching. You can see it this month in the morning sky--bright, steady and remarkably red. Only Venus near the sun is brighter.

Amateur astronomers looking through backyard telescopes have reported in recent days great views of Mars's south polar cap. Made of frozen water and carbon dioxide ("dry ice"), it reflects sunlight well. On June 1st Mars was 12.5 arcseconds across and it glowed like a -1st magnitude star. On August 27th it will be twice as wide (25 arcseconds) and six times brighter (magnitude -2.9).

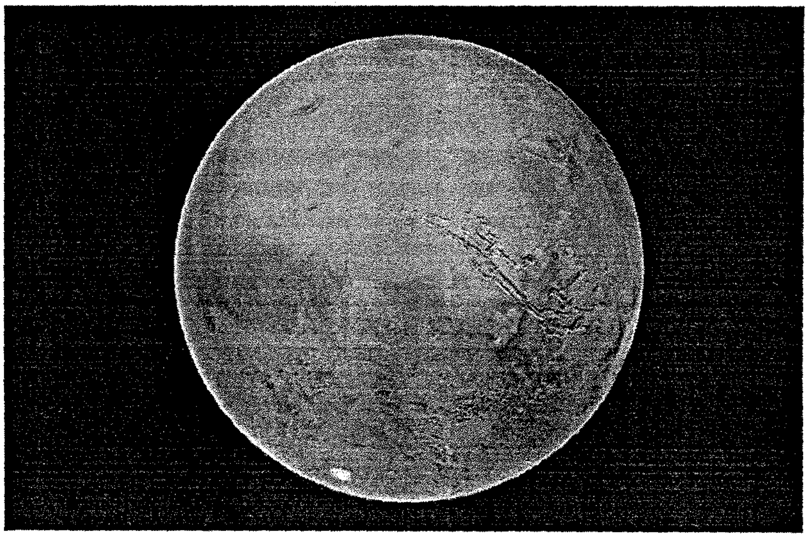
Much has been made of the fact that the August 27th encounter with Mars is the closest in some 60,000 years. Neanderthals were the last to observe Mars so favorably placed. This is true. It's also a bit of hype.

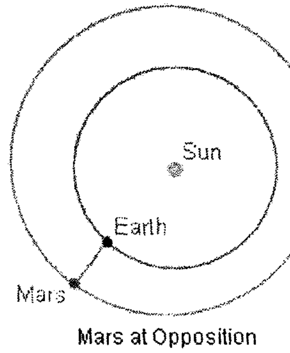
Mars and Earth have been almost this close many times in recent history. Some examples: Aug. 23, 1924; Aug. 18, 1845; Aug. 13, 1766. In each case Mars and Earth were approximately 56 million km apart.

Astronomers call these close encounters "perihelic oppositions." Perihelic means Mars is near perihelion--its closest approach to the sun. (The orbit of Mars, like that of all planets, is an ellipse, so the distance between the sun and Mars varies.) Opposition means that the sun, Earth and Mars are in a straight line with Earth in the middle. Mars and the sun are on opposite sides of the sky. When Mars is at opposition and at perihelion--at the same time--it is very close to Earth.

August 27th is indeed the best perihelic opposition since the days of the Neanderthals, but it scarcely differs from other more recent ones. That's fine because all perihelic oppositions of Mars are spectacular.

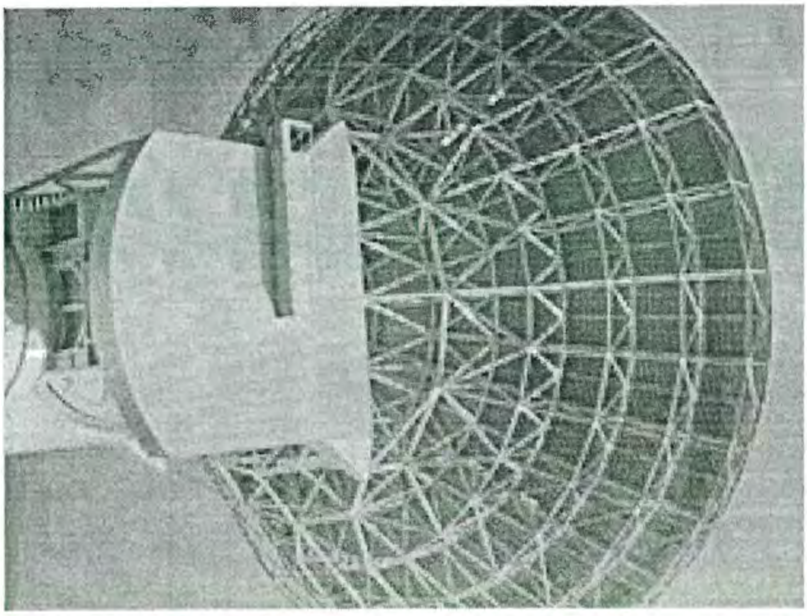
http://science.nasa.gov/headlines/y2003/18jun_approachingmars.htm





Mars at Opposition

NEW NORCIA TRIP



Images by Sascha Schediwy.
Just some images from the New Norcia field trip. Another great and interesting time was had by all, although apparently the lunch could have been better.

BIRCHEE'S WORD

Hi ALL. At the next vollie meeting - JULY 28 - I will give a full run down of the Observatory numbers on tours etc - and compare with the last few years worth of data.

Brochures are now available giving dates for tours for the complete season.

The revised tour methodology - less week nights, more weekends, will also be discussed.

Further, as MARS is now big and bright, and soon to be the subject of YOUR tour night, I will give a presentation on Mars, including enough ammo for you to keep the visitors impressed with your boundless store of knowledge.

Noticed how bright Mars is in the East at around 9pm?? Maybe you've noticed it in the NW at 6am ?? If not, put your woolies on and get out there...

Astronomy is looking up.

Peter B.

"*Fishing is a state of mind where one cannot possibly have a bad time*": Zane Gray, 1924

POVG MEETING - MINUTES

Meeting Commenced at 7.15pm. under Vice Chairman K.Kotze.

Attendance. J.Alcroft. K.Kotze. G.Colletti. F.Bilki. V.Smith. T.Beardsmore. T.Smith. J.Morris. G.Lowe. J.Biggs. E.Walker. J.Milner. T.Beston. M.Freeman. E.Cowlishaw. D.Alderton. L.Martin. V.Semmler. B.Harris. L.Robinson.

Apologies.
L.Bell. R.Boelen. B.Hollebon. J.Bell. T.Dunn.

Minutes of the Previous Meeting. Were moved as a true and correct record on the Motion of B.Harris. seconded T.Beston.

Matters arising from the Minutes. K.Kotze reported that the Shoemaker Impact Crater trip had not attracted enough takers to make it viable, but thanked M.Freeman for his efforts.

Treasurers Report.
B.Harris stated that after a call and a meeting with a person from the Taxation Office regarding G.S.T. they were now satisfied with the way the matter had been handled. We had received a refund from the Tax Office of $86.00 , plus a further refund of $8.00. The Bank statement was now $118.13

General Business.
K.Kotze thanked and congratulated J.Biggs for the very pleasant and interesting trip to New Norcia, 35 people had attended and had a very enjoyable day. J.Biggs responded by saying that the Observatory was very grateful for, and appreciated the efforts of the Volunteers and this was one way of saying Thank You. L.Martin reported that a letter had been received from the CommunityFacilities Grants Program stating that our application for funds had not been successful.

There being no further General Business the Meeting closed at 7.40pm

SKYWATCH FOR AUGUST

All Month - Mercury now easy to spot (without a telescope) in the early evening sky above the Western horizon.

1st - Alpha Capricornids meteor shower peak.
4th - Neptune At Opposition. · 6th - Southern Iota Aquarids meteor shower peak.
12th - Full Moon. Avoid nights around this date for star parties.
13th & 14th - The Moon passes Mars.
14th - Mercury greatest Eastern elongation (27 Degrees).
16th - Asteroid 37655 (1994 PM) near-Earth flyby (0.025 AU).
23rd - 25th - The Moon passes Saturn and the stars Castor and Pollux (the brightest stars in the constellation Gemini The Twins) (morning sky).
24th - Uranus at Opposition.
25th - Northern Iota Aquarids Meteor Shower Peak.
25th - Asteroid 2000 BM19 near-Mercury flyby (0.045 AU).
27th - Asteroid 1998 CS1 near-Venus flyby (0.033 AU).
28th - Mars reaches opposition. Mars makes it closest approach to Earth since 1924 (56 million km), and is closer than it will be again until the year 2287 (from http://heritage.stsci.edu/2001/24/supplemental.html).
28th - Asteroid 2002 JR100 near-Earth flyby (0.050 AU)

http://www.ozskywatch.com/amaz/space/skyevent/2003/summary.html#anchor488707

MOON PHASES - AUGUST 2003

2nd Quarter ~ August 5th 2:28AM Scorpio

Full Moon ~ August 11th 11:48PM Aquarius

4th Quarter ~ August 19th 7:48PM Taurus

New Moon ~ August 27th 12:26PM Virgo

CONGRATULATIONS AND THANK YOU

Dear Vollies
I just been reviewing the performance measures for 2002/2003. We set a new Observatory visitor attendance record of 9,772 in 2002/2003, up 68 from the number in 2001/2002!

Congratulations and thank you for directly, or indirectly, assisting with this accomplishment.
Regards, Jamie.

PERTH OBSERVATORY VOLUNTEERS GROUP INC.
MEMBER LIST

JEFF ALCROFT
DICK ALDERSON
JEANNE BELL
TREVOR BEARDSMORE
LYALL BELL
FRANK BILKI
TONY BESTON
RIC BOELEN
EVE COWLISHAW
GIUSEPPE COLETTI
PETER CRAKE,
TREVOR DUNN
DAVID EMICH
MARCEL FORTSCH
MIKE FREEMAN
LYNDA FREWER
BEVAN HARRIS
DON HARTLEY
MARK HASLAM
JAMES HEALY
BERT HOLLEBON
KAREN KOTZE
ERIN LALOR
VIC LEVIS
ROB LONEY
ANDREW MACNAUGHTAN
LEN MARTIN
JACQUIE MILNER
JOHN MORRIS
KYLIE RALPH
LLOYD ROBINSON
SASCHA SCHEDIWY
VAL SEMMLER
VERA SMITH
ROBERT TAYLOR,
PATRICIA TURNER
ELAINE WALKER
SANDRA WALKER
MATTHEW ZENGERER

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

Trevor Dunn	POVG Inc, Chairperson
Karen Koltze	POVG Inc, Vice Chair
Bob Taylor	POVG Inc, Secretary
Bevan Harris	POVG Inc, Treasurer and newsgroup

moderator (contact bevan on ngc2070@bigpond.com)

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

HAPPY BIRTHDAY VOLLIES & STAFF FOR JUNE & AUGUST

Eve Cowlishaw, Greg Lowe, Ralph Martin, Lyall Bell

2003/2004 TRAINING NIGHTS SCHEDULE

2003	2004
May 26	Jan 19
Jun 30	Feb 23
Jul 28	Mar 15
Aug 25	Apr 19
Sep 22	May 17
Oct 20	Jun 14
Nov 24	Jul 12
	Aug 9

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated.
Jamie Biggs. Govt Astronomer

POVG
Perth Observatory Volunteers Group

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

VollieNews

SEPTEMBER 2003

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

HIGHLIGHTS FROM THE PERTH OBSERVATORY REPORT 2002/2003

· **New annual visitor attendance record**
· **Implementation of star viewing for people with disabilities**
· **Successful total solar eclipse expedition to Ceduna, SA**
· **Successful production of the annual astronomy almanac for WA**

Observatory activities in the past year have remained focussed on its three core functions of education, information and research. Some areas have experienced significant improvement and this will be detailed below, whilst others continue with relatively steady output or an increase in capability.

In 2002/2003 a new visitor attendance record of 9,772 was set. This accomplishment was mainly the result of a record number of 3,827 visitors on our daytime guided tours. Star viewing nights continue to be popular with the public and the yearly attendance totalled 5,653. Observatory visitor's satisfaction remained high as in previous years, with more than 94 per cent both satisfied with their visit, and, with the educational quality of the services in which they participated.

Access to the Perth Observatory Star viewing night programme was expanded to include people with disabilities with the formal dedication and utilisation of specialised equipment acquired by the Perth Observatory Volunteer Group. The equipment consists of a specialised telescope and mount that can be adjusted to the height of the observer, and not vice versa as is the usual practice. Also, specialised video cameras, monitors and control equipment were installed in order to provide an accessible view of celestial objects for people with restricted mobility and sight. The general public can also use this equipment and this serves to integrate people with disabilities into mainstream activities. Furthermore, advice on how to maximise the use of this equipment by people with disabilities was obtained from the relevant authorities such as the Department of Disability Services, the Independent Living Centre and Recnet.

Acquisition of the portable data projector and laptop PC enabled the successful implementation of off-site PC-based astronomy presentations. In 2002/2003 a total of 82 lectures and the like were conducted by Observatory staff to a total audience of 1,990. Star viewing was also provided to rural and metropolitan, schools and communities. All up, more than 2,496 people viewed the stars with Observatory telescopes transported to their locality for one of 23 'astronomy field nights' conducted during the financial year.

Observatory staff and volunteers successfully mounted an expedition to witness the total solar eclipse at Ceduna, SA, on the 4th December 2002. 24 members of the general public who enjoyed the spectacle immensely accompanied them. An Ha ?telescope was acquired and safely provided all expeditioners with a detailed view of the Sun. This instrument is also regularly used to show the Sun to daytime visitors to the Observatory.

Formal education activities provided by the Observatory included a new Honours-level astrophysics course at Curtin University, the continuation of a second-year practical astronomy course at

Curtin University, as well as participation in the multi-disciplinary first-year course containing a large component of astronomy at the University of Western Australia. Also, five university students were supervised in their research projects. Two had Summer Studentships, with one involved tracking asteroids and comets, and another worked on modelling the behaviour of pulsars in binary orbits. Another two students researched the properties of asteroids, and another explored upgrading our 16" telescope for scientific observations.

Public awareness of the Observatory also remains high. The Perth Royal Agricultural Show provided a venue to promote the Observatory to the general public. This activity was reasonably successful as over 7,000 Observatory brochures were distributed to the public and several bookings for the eclipse expedition were secured there. In 2002/2003 the number of people who visited, 'phoned for information (9,872), attended talks, or attended an astronomy field night, totalled 26,240 (28,119 in 2001/2002). Observatory staff also informed the public of astronomical events in 62 radio and 5 television interviews, and 69 newspaper articles. A significant fraction of this media interaction concerned the solar eclipse of 4th December 2002.

In 2002 the full responsibility for the production of the annual astronomy almanac for WA was resumed by Perth Observatory. This arrangement has the virtue of being more responsive to the needs of the local users of this resource. The 2003 almanac was the first in the new format and user feedback has been uniformly positive.

The tragic destruction of the Mount Stromlo Observatory, near Canberra, by bushfire was a great blow to Australian astronomy. Like many other organisations, Perth

Observatory organised events to raise funds for the Mt Stromlo disaster relief effort.

Our annual Summer Lecture raised $800 and an astronomy night held in conjunction with Scitech raised over $5,000 for Mt Stromlo Observatory.

Volunteers have again most ably assisted permanent staff in many activities, notably, the Star Viewing Nights, archiving, and at displays. Volunteer assistance totalled 0.83 FTEs in 2002/2003 and continues to make an important contribution to the Observatory output.

Perth Observatory's research has diversified a little over the year with the inclusion of the study of Gamma Ray Burst (GRB) supernovae in the supernova search programme. An ANU PhD student whose work was adversely affected after the destruction of Mt Stromlo Observatory provided the prime motivation to undertake this line of work However, this work is well aligned with the current programme and capitalises on the Observatory's growing expertise in photometry and telescope automation. A substantial effort went into developing software that automatically controls the Perth-Lowell Automatic Telescope (PLAT) in an effort to promptly detect optical counterparts of GRBs (detected by orbiting satellites) in response to email notification from the GRB Notification Centre.

Searching for planetary transits (where a planet blocks out the light of the star it orbits, for a few hours at a time) has been added to the gravitational microlensing technique (where a star's brightness is enhanced by the passage of a faint foreground star in front of it) in the PLANET project. This project's homebase (team coordination and data management) was also hosted by Perth Observatory in August 2002.

Fully unattended operation has become the norm for all observing with the PLAT over the past year, but usually later than around midnight due to the need for manually refocussing the telescope as temperatures fall during the night. This operation also utilises data from the Observatory cloud detector and overall this has resulted in a threefold increase in the number of images collected by the PLAT this year. Development of a new schedular is progressing, and has been run in trial form for approximately 20 nights. It can manage PLANET observing, as well as other tasks like the Supernova Search. While the telescope is running, members of the PLANET group (still awake, in different time zones) can directly alter the object priorities and sample rates in real time, responding to anomalous behaviour in any event. Perth is the only PLANET telescope using any form of automated observing.

Work on variable stars bore fruit with two refereed papers published concerning some of these objects. Comet observations were hampered by a lack of suitable targets but preparation of papers based on earlier observations continued.

In 2002/2003, a total of 402 (278 asteroid and 124 comet) minor body positions were published. Six of these were confirmation observations for a newly discovered Near Earth Object (NEO), and 165 were useful observations of 35 other NEOs necessary to refine their orbits. One paper was published on our unsuccessful attempt to recover a potentially hazardous asteroid, 1999 OX4. Fortunately, this null detection means that it will not have a close encounter with the Earth in 2014. Also, observations progressed in a search for asteroids in the Lagrangian points of the Earth's orbit. The search we have undertaken is the most extensive conducted to date, but no asteroids of this type brighter than V~17.5 were discovered.

All of the above achievements could not have been accomplished without the consistent effort and commitment of all the Observatory staff, both permanent and volunteer.

(Extracted from the forthcoming CALM annual Report)

OBSERVATORY PERFORMANCE MEASURES 2002-03

	Target	Actual	Explanation of significant variation
Tour visitors	8,800	9,772	Greater than expected attendance at daytime guided tours.
Enquiries	19,100	16,468	Given limited staff numbers, this activity decreased as the number of visitors increased.
Refereed scientific papers	5	3	This decrease reflects the inherent fluctuation in the number of papers associated with the ongoing, protracted and complex nature of the research output, the external collaboration required, and the relatively small number of papers involved each year.
QUALITY			
Positive responses to 'quality' measures in customer surveys	99%	98%	
Submitted research papers published in international refereed journals	100%	100%	
TIMELINESS			
Satisfaction of information requests as they occur	95%	98%	
Timely publication of research papers in international refereed journals	100%	100%	
Effective study of astronomical targets of opportunity as they occur-ereed research paper	57%	91%	This increase reflects the observing assistance provided by summer students.
COST			
Cost per tour visit or	$18.15	$21.90	This increase is mainly due to an increase in the number of daytime guided tours that don't quite recover full cost.
Cost per enquiry	$32.5	$35.72	
Cost of research activities per ref	$85,000	$134,239	This increase reflects the ongoing, protracted and complex nature of the research output, the external collaboration required, and the relatively small number of papers involved each year.
Cost of research activities per 1,000 head of population	$189	$208	

NEMESIS

'An agent of retribution or punishment quotes the MacQuarie dictionary, and the word actually stems from the Greek Goddess of punishment.

In modern astronomical, it is the name given to the hypothesized star that orbits our own Sun. Davis and others (Davis, M., Hutt, P., and Muller, R.A., 1984. Extinction of species by periodic comet showers. Nature, 308:715-717) identified what they interpreted as a periodicity of about 27 Ma in the major extinction events throughout the last 540†Ma of geological history (the time through which diverse life has existed on Earth).

Major extinctions can be, at least partly, related to impacts of large extraterrestrial objects, epitomized by the Chixulub impact at 63 Ma, related to the extinction of the dinosaurs.

The model devised was that another 'sun' orbited our own Sun at a distance of about 3 light years, and has an eccentric orbit. At this distance it would have an orbital period of about 27 Ma. If its orbit was circular, it would remain outside of the Oort cloud of nascent comets that orbit at distances of up to about 2 light years (or about 160†000 AU), and would probably not have any significant effect on the bodies. However, if it has an orbit with an eccentricity of about 0.5, this star would approach to within 1 light year, and that would bring it to well within the Oort cloud.

Any smallish star, passing within the Oort cloud would have a major effect on the orbits of many of the ìcometsî, throwing them out of stable orbits and sending them in all directions. They would be sent both outwards, ejecting them from our solar system (if you can include the Oort cloud as part of the System) and inwards, sending them towards the parent Sun. It is these latter incoming comets that, if they then attained earth-crossing paths, could collide with the Earth. That is the reason why Davis used the name Nemesis for this hypothesized star.

What can be observed to support this theory? Nothing as yet. Even the periodicity identified by Davis is subject o criticism from other scientists, because there are other major extinction events in the palaeontological record that do not correlate with the 27†Ma. However, there are other events that are known to cause extinctions. For example, a major extinction at the end of Permian time, about 180 million years ago (and, for your edification, the Collie coals that provide us with about 30% of our electricity were formed during Permian times) is correlated with the extrusion of thousands of cubic kilometres of basalt lavas in Russia that produced enough carbon dioxide and sulphur dioxide to make the atmosphere and hydrosphere toxic to life. So, to arrive at this periodicity requires selection of some only of all the identified extinctions.

Should we expect to observe the orbiting star through Earth-bound telescopes? Possibly. However, if it was a red dwarf with a low illumination level, such a star may easily be missed, particularly if it was in a densely populated part of the sky. It might even be concealed behind a dust cloud on the outer edges of our solar system.

A major ESA astronomical satellite, Hipparcos was designed to plot the locations of stars, commencing in 1989, and monitor their relative motions over a period of years. However, its launch vehicle failed to function properly and when it completed its life, Hipparcos had only observed about 25% of the sky, and therefore was not able to provide clear evidence for or against such a star. Current planning revolves around future satellites with greater observing power and resolution, being able to identify stars such as small red dwarfs down to 10th magnitude. In the meantime, more analysis of extinction events, better identification of impact-related extinctions and work on trying to identify comet showers is being tackled. The big question they are all leading to is can we expect another major extraterrestrial impact that could spell disaster for humans.

Mike Freeman

2003/2004 TRAINING NIGHTS SCHEDULE

2003	2004
May 26	Jan 19
Jun 30	Feb 23
Jul 28	Mar 15
Aug 25	Apr 19
Sep 22	May 17
Oct 20	Jun 14
Nov 24	Jul 12
	Aug 9

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

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This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

MARS - FACT SHEET

Mars is dry as a desert, despite clear evidence that water once flowed freely across its surface.Where did Mars' water go?

Mars, the Red Planet, has inspired wild flights of imagination over the centuries, and intense scientific interest. Fancied to be the source of hostile invaders of Earth, the home of a dying civilization, and a rough-and-tumble mining colony of the future, Mars has proved to be fertile ground for science fiction writers, based on seeds planted by centuries of scientific observation. Mars has shown itself to be the most Earth-like of all the planets; it has polar ice caps that grow and recede with the change of seasons, and markings that appear to be similar to water channels on Earth.

We know that Mars is a small rocky body once thought to be very Earth-like. Like the other "terrestrial" planets - Mercury, Venus, and Earth - its surface has been changed by volcanism, impacts from other bodies, movements of its crust, and atmospheric effects such as dust storms. It has polar ice caps that grow and recede with the change of seasons; areas of layered soils near the Martian poles suggest that the planet's climate has changed more than once, perhaps caused by a regular change in the planet's orbit. Martian tectonism - the formation and change of a planet's crust - differs from Earth's. Where Earth tectonics involve sliding plates that grind against each other or spread apart in the seafloors, Martian tectonics seem to be vertical, with hot lava pushing upwards through the crust to the surface. Periodically, great duststorms engulf the entire planet. The effects of these storms are dramatic, including giant dunes, wind streaks, and wind-carved features.

Scientists believe that 3.5 billion years ago, Mars experienced the largest known floods in the solar system. This water may even have pooled into lakes or shallow oceans. But where did the ancient flood water come from, how long did it last, and where did it go?

In May 2002, scientists announced the discovery of a key piece in the puzzle: the Mars Odyssey spacecraft had detected larged quantities of water ice close to the surface - enough to fill Lake Michigan twice over. The ice is mixed into the soil only a meter (about 3 feet) below the surface of a wide area near the Martian south pole.

Many questions remain. At present, Mars is too cold and its atmosphere is too thin to allow liquid water to exist at the surface forlong. More water exists frozen in the polar ice caps, and enough water exists to form ice clouds, but the quantity of water required to carve Mars' great channels and flood plains is not evident on - or near - the surface today. Images from NASA's Mars Global Surveyor spacecraft suggest that underground reserves of water may break through the surface as springs. The answers may lie deep beneath Mars' red soil.

Unraveling the story of water on Mars is important to unlocking its past climate history, which will help us understand the evolution of all planets, including our own. Water is also believed to be a central ingredient for the initiation of life; the evidence of past or present water on Mars is expected to hold clues about past or present life on Mars, as well as the potential for life elsewhere in the universe. And, before humans can safely go to Mars, we need to know much more about the planet's environment, including the availability of resources such as water.

Mars has some remarkable geological characteristics, including the largest volcanic mountain in the solar system, Olympus Mons (27 km high and 600 km across); volcanoes in the northern Tharsis region that are so huge they deform the planet's roundness; and a gigantic equatorial rift valley, the Valles Marineris. This canyon system stretches a distance equivalent to the distance from New York to Los Angeles; Arizona's Grand Canyon could easily fit into one of the side canyons of this great chasm.

Mars also has two small moons, Phobos and Deimos. Although no one knows how they formed, they may be asteroids snared by Mars' gravity.

http://sse.jpl.nasa.gov/features/planets/mars/mars.html

Distance from the Sun (Semimajor axis of orbit)	227,936,640 km 1.52366231 A.U.
Mean Equatorial Radius	3,397 km (0.5326 of Earth's radius)
Volume (Earth = 1)	0.149
Mass:	0.64191 x 1027 kg
Density	3.94 gm/cm3
Surface Gravity:	371 cm/s2
Escape Velocity	5.02 km/s
Sidereal Rotation Period (Earth days):	1.02595675
Sidereal Orbit Period (Earth years)	1.88071105
Mean Orbit Velocity	24.1309 km/s
Orbit Eccentricity	0.09341233
Orbit Inclination to Ecliptic	1.85061 degrees
Inclination of Equator to Orbit	25.19 degrees
Mean Temperature at Solid Surface	186 to 268 K
Major Atmospheric Constituents	1CO2, N2, Ar

http://www.astronomy-info.com/SolSys/Mars.html

NASA SEEKS PUBLIC SUGGESTIONS FOR MARS PHOTOS

Earth comes closer to Mars this month than it has in nearly 60,000 years, but one new opportunity for seeing details on the red planet comes from a vantage point much closer.

The public has an unprecedented opportunity to suggest places on Mars that should be photographed from a spacecraft orbiting that planet. Camera operators for NASA's Mars Global Surveyor spacecraft are ready to take suggestions online for new places for images from the Mars Orbiter Camera.

The spacecraft, managed by NASA's (JPL), Pasadena, Calif., has been orbiting Mars since 1997, with more than 20,000 orbits so far. The Mars Orbiter Camera has already taken more than 120,000 pictures of Mars. Many of the camera's images have sharp enough resolution to show features as small as a school bus. The images have revealed relatively recent gully erosion, ancient sedimentary rocks and many other spectacular scientific surprises.

"We've only covered about three percent of the surface area of Mars with the high-resolution camera. We want to be sure we're not missing some place that could be important, so we're casting a wide net for new suggestions," said Dr. Ken Edgett, staff scientist at Malin Space Science Systems, the San Diego firm that supplied and operates the camera for NASA. "We're looking for excellent suggestions of areas on Mars that we have not already imaged," Edgett said. "We'll look at every request that comes in."

"NASA's Mars Global Surveyor spacecraft team will examine each request to ensure the safety of this priceless 'eye in the sky' above Mars," said Dr. Jim Garvin, NASA's Lead Scientist for Mars Exploration at NASA Headquarters, Washington.

Information about how to submit requests is online at the new Mars Orbiter Camera Target Request Site, at:

http://www.msss.com/plan/intro

Requesters should describe the purpose for the suggested image. Suggestions for target sites already imaged by the camera will be disqualified unless there is a convincing reason for repeating the target. An online gallery of pictures taken by the camera is at:

http://www.msss.com/moc_gallery/

"Some of the best requests may be places nowhere near any site the Mars Orbiter Camera has imaged before," Edgett said. As with pictures desired by Mars scientists working with the camera every day, new suggestions will need to wait until the Mars Global Surveyor flies directly over the selected target, which could be several months or longer. The first images from this public suggestion program will probably be released this fall.

NASA NEWS RELEASE Posted: August 20, 2003
http://spaceflightnow.com/news/n0308/20marssuggest/

HUBBLE HAS VIEWING PLANS FOR 'CLOSE ENCOUNTER' WITH MARS

NASA's Hubble Space Telescope (HST) will make observations of the planet Mars on Aug. 26-27. As soon as Hubble's high-resolution images of the Red Planet are received at the Space Telescope Science Institute (STScI) and are digitally processed by the Mars observing team, they will be released to the public and news media via the Internet.

High-resolution files for downloading will available on HubbleSite News Center at **http://hubblesite.org/newscenter/2003/22,** beginning at 6 a.m. EDT Aug. 27.

The Hubble images will be the sharpest views of Mars ever taken from Earth. They will reveal surface details as small as 17 miles (24 km) across. Though NASA's Mars-orbiting spacecraft can photograph the Red Planet in much finer detail, Hubble routinely serves as a "weather satellite" for tracking atmospheric changes on Mars and for probing its geology on a global scale. Unlike "real-time" viewing through ground-based telescopes, Hubble observations are carried out automatically by the orbiting observatory. Free of clouds and atmospheric distortion, Hubble is guaranteed a front-row seat to the celestial close encounter. The images will be stored in an onboard computer, transmitted to the Goddard Space Flight Center in Greenbelt, Md., and then to the Space Telescope Science Institute. Once received at STScI, the images will be calibrated and combined to make a natural, full-color view of Mars. A key image-processing step will be to combine and register images taken through different filters. Because Mars rotates a little between each Hubble exposure, each separate picture must be precisely aligned to make a color image. This means several hours will elapse from the time of a Hubble observation to the assembly of a full-color image.

Two close-approach images will be posted on the Internet on Aug. 27. The first view, taken the evening of Aug. 26, when Mars is 34,648,840 miles (55,760,220 km) from Earth, will be posted as a full-resolution color image for downloading after approximately 6 a.m. EDT.

In the second image, taken within an hour of "closest approach," Mars will be merely 1,400 miles closer than the previous exposure. It will be at its closest distance of 34,647,420 miles (55,757,930 km). The resolution will effectively be the same as in the earlier image.

The image-processed color pictures will be posted on the Internet after 4 p.m. EDT Aug. 27. Mars researchers Jim Bell of Cornell University in Ithaca, N.Y., and Michael Wolff of the Space Science Institute in Boulder, Colo., will be at STScI and available for media interviews beginning at 5 a.m. EDT Aug. 27.

SPACE TELESCOPE SCIENCE INSTITUTE NEWS RELEASE Posted: August 20, 2003
http://spaceflightnow.com/news/n0308/20marshubble/

SKY EVENTS FOR SEPTEMBER

1	Moon at perigee, its closest to the Earth for the Lunar month, 367928 km, (August 31, 18 hrs UT).
3	Half lit Moon about 3.5° below 1st magnitude star Antares.
4	Moon at first quarter 12:34 am NZST (Nov 3, 12:34 UT).
8 - 10	Moon passes Mars (evening sky). 9/10 Mars about 1.5° from 98% lit Moon at midnight NZ.
11	Full Moon at 4:36 am NZST (Sep 10, 16:36 UT). Mercury at inferior conjunction.
12	Ceres passes Saturn, less than 1° apart at closest.
16	Moon at apogee, its greatest distance from the Earth for the Lunar month, 404713 km. Asteroid 2000 GF2 near-Earth flyby (0.012 AU).
19	Moon at last quarter 7:03 am NZST (Sep 18, 19:03 UT). Mercury stationary.
20 - 22	The Moon passes Saturn, and the stars Castor and Pollux (the brightest stars in the constellation Gemini The Twins) (morning sky).
22	The Galileo spacecraft will impact Jupiter's cloud top rather than risking contamination of Jupiter's Moon Europa.
23	SPRING EQUINOX* at 11 pm NZST (11 hours UT). Sun crosses equator moving south.
26	New Moon at 3:09 pm NZST (03:09 UT).
27	Mercury at greatest elongation, 18° west of Sun.
28	Moon at perigee, its closest to the Earth for the Lunar month, 362837 km. Second perigee for NZ this month.
30	Mars stationary.

http://www.rasnz.org.nz/SolarSys/Sep_03.htm and http://www.ozskywatch.com/amaz/space/skyevent/2003/summary.html#anchor489409

SEPTEMBER 23 - SPRING EQUINOX

* EQUINOX

Two times of the year when night and day are about the same length. The Sun is crossing the Equator (an imaginary line around the middle of the Earth) and it is an equal distance from the North Pole and the South Pole.

SPRING EQUINOX:

The first day of the Season of Spring - and the beginning of a long period of sunlight at the Pole. In the northern hemisphere: MARCH 20 (the Sun crosses the Equator moving northward). In the southern hemisphere: SEPTEMBER 22 (the Sun crosses the Equator moving southward).

http://www.athropolis.com/sunrise/def-sol2.htm

A VERY HAPPY BIRTHDAY TO VOLLIES & STAFF FOR SEPTEMBER

Trevor Dunn
David Emich
Keith Ford
Mike Freeman
James Healy
Bert Hollebon
Val Semmler
Sheryle Smith
Arie Verveer

PHASES OF THE MOON FOR 2003 (WA TIME)

New Moon		First Quarter		Full Moon		Last Quarter	
Jan 3	04:23	Jan 10	21:15	Jan 18	18:47	Jan 25	16:33
Feb 11	08:48	Feb 9	19:11	Feb 17	07:51	Feb 24	00:46
Mar 31	00:35	Mar 11	15:15	Mar 18	18:34	Mar 25	09:51
Apr 2	03:18	Apr 10	07:40	Apr 17	03:35	Apr 23	20:18
May 01	20:15	May 09	19:53	May 16	11:36	May 23	08:30
May 31	12:20	Jun 08	04:27	Jun 14	19:16	Jun 21	22:45
Jun 30	02:38	Jul 07	10:32	Jul 14	03:21	Jul 21	15:01
Jul 29	14:53	Aug 05	15:27	Aug 12	12:48	Aug 20	08:48
Aug 28	01:26	**Sep 03**	**20:34**	**Sep 11**	**00:36**	**Sep 19**	**03:03**
Sep 26	**11:09**	Oct 03	03:09	Oct 10	15:27	Oct 18	20:31
Oct 25	20:50	Nov 01	12:25	Nov 09	09:13	Nov 17	12:15
Nov 24	06:59	Dec 01	01:16	Dec 09	04:37	Dec 17	01:42
Dec 23	17:43	Dec 30	18:03				

http://www.wa.gov.au/perthobs/hpc5mn03.htm

POVG
Perth Observatory Volunteers Group

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

PERTH OBSERVATORY VOLUNTEERS GROUP INC.

VOLUNTEER MEMBER LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake,
Trevor Dunn
David Emich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
James Healy
Bert Hollebon
Karen Kotze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Kylie Ralph
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Robert Taylor,
Patricia Turner
Elaine Walker
Sandra Walker
Matthew Zengerer

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

Trevor Dunn	POVG Inc, Chairperson
Karen Koltze	POVG Inc, Vice Chair
Bob Taylor	POVG Inc, Secretary
Bevan Harris	POVG Inc, Treasurer and newsgroup

moderator (contact bevan on ngc2070@bigpond.com)

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

POVG MEETING - MINUTES

Minutes of Meeting July 28th
Meeting Commenced at 7pm

Attendance.

J.Alcroft. T.Smith. V.Smith. B.Hollebon. K.Kotze. S.SchediwyG.Lowe. K.Ford. D.Alderson. G.Coletti. M.Zengerer. E.Walker. A.Williams. P.Birch. J.Morris

Apologies.

T.Dunn. L.Bell. J.Bell. B.Harris. T.Beardsmore. L.Frewer. D.Hartley. M.Haslam. L.Martin. T.Turner. M.Freeman.

Minutes of the Previous Meeting.

Agreed as a true and correct record on the motion of J.Alcroft Seconded by J.Milner.

Treasurers Report.

In the absence of the Treasurer G.Lowe reported that Funds now stood at G.S.T payments refunded $86.00 bringing the Bank Balance to $204.00. B.A.S claim has been submitted for $8.00

General Business.

There being no items of General Business to be Discussed the Meeting closed at 7.15pm

POVG
Perth Observatory Volunteers Group

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

Conservation News Nov 2002

David Tiggerdine at the Perth Observatory. Photo by Norm Bailey.

Pennies from heaven

WESTERN Power and Water Corporation meter readers were dispatched to the Perth Observatory in Bickley to cast a critical eye over Departmental operations.

The bills had dropped so much that both utilities were concerned that something strange was going on.

What they found, however, was greatly improved efficiency in the use of water and electricity.

Perth Observatory employee, David Tiggerdine has been responsible for:

- putting heating on timers;
- using infrared light to stop condensation's on telescopes;
- improving irrigation systems;
- connecting two hot water systems into one system; and
- changing refrigerators.

So far the Observatory electricity bills have been halved with an $ 11,000 saving in the last two years - no mean feat as Observatory staff already believed themselves to be energy efficient. Power bills dropped from $23,000 in 1998 to $ 12,000 this year.

As a consequence, the Federal Government 'Greenhouse building energy rating - a computer program that measures the efficiency of space versus energy consumption - rose from 3.5 to 5 stars.

"You know you've done a good job when Western Power and the Water Corporation check their meters, but there are more savings we can achieve," David said.

His new plans include:

- putting electronic ballasts **on triphosphor** fluoroglobes to achieve a 30 per cent improvement on lighting efficiency; **and**
- buying a heat exchanger to reduce the **air** conditioning accounts by 70 per cent. David worked with technical staff Arie Verveer and John Pearse to implement the changes. He also points out that case studies around the world showed energy efficient buildings enhanced work satisfaction and reduced staff sickness, leading to a more effective working environment.

Government Astronomer Dr Jamie Biggs said that David's work had been a big help, particularly since the Observatory budget was getting tighter.

VollieNews

NOVEMBER 2003

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

STAR VIEWING NIGHT RECORD SET IN SEPTEMBER

The Mars viewing sessions have worked really well and gone a long way to meet public demand. The extra sessions scheduled resulted in the Observing a new record with monthly attendance of 1,208. Also, the cumulative attendance at 1,584 (includes visitors from July and August) is by far the highest it been at the end of September. Well done everybody. Regards, Jamie.

A NEW MOON FOR NEPTUNE

The outer solar system just got a little more crowded, as astronomers have discovered another small moon circling Neptune. The new find, designated S/2003 N1, travels in a distant and highly irregular orbit that averages nearly 50 million miles from the planet and takes 26.3 years to complete one revolution. Observers David C. Jewitt, Jan Kleyna, and Scott S. Sheppard identified the tiny object, about 40 kilometres across, as a 26th-magnitude blip in images acquired on August 29th with the giant Subaru telescope atop Mauna Kea, Hawaii. Based on orbital calculations by Brian G. Marsden (Minor Planet Center), its motion was matched to that of an object first seen in August 2001 and two times thereafter. S/2003 N1 is Neptune's 12th satellite.

In 1999, while inspecting 13-year-old images taken of Uranus by Voyager 2, planetary specialist Erich Karkoschka (University of Arizona) spotted a tiny moonlet circling about 50,000 kilometres above the blue-hued planet. But because it was so faint and small, no more than 40 km across, his find could not be confirmed by telescopes back on Earth. Consequently, two years ago the International Astronomical Union decided to remove S/1986 U10 from its official list of Uranian satellites. But thanks to observations made August 25th using the Hubble Space Telescope's new Advanced Camera for Surveys, Karkoschka's claim has been verified. Mark R. Showwalter (Stanford University) and Jack J. Lissauer (NASA/Ames Research Center) found the 24th-magnitude object about 48 degrees ahead of its predicted position. S/1986 U10 circles Uranus every 15.3 hours and is the planet's 22nd known moon.

Peter Birch Astronomy is Looking up !!

POVG MEETING - MINUTES

Perth Observatory Volunteer Group Inc.
Minutes of Meeting 22nd September 2003

Present.
R.Loney. T.Smith. D.Hartley. J.Morris. T.Beardsmore. D.Emrich T.Beston. R.Boelen. J.Alcroft. G.Lowe. M.Haslam. J.Milner. G.Colletti M.Freeman. L.Robinson.

Apologies.
F.Bilki. L.Bell. B.Hollebon. D.Alderson. R.Taylor. E.Walker. T.Dunn. E.Cowlishaw. K.Kotze.

In the absence of T.Dunn and K.Kotze the meeting was Chaired by J.Morris at 7.17pm

Minutes of the previous meeting were signed as a true and correct record on the Motion of T.Beston Seconded by J.Alcroft

Treasurer's Report.
B.Harris stated that the financial situation was unchanged since the August Meeting.

Matters Arising from the minutes.
None.

General Business.
J.Biggs stated that there had been a number of occasions when volunteers had failed to arrive at the Observatory on nights that they had nominated to attend, and that people were not nominating for Standby nights. This combination had caused problems, particularly when Tours were fully booked. Please ensure that if circumstances are such that you are unable to attend , that you ring the Observatory in time for someone else to be contacted.

J.Biggs informed the meeting that Tom Smith had tendered his resignation and would be finishing his duties at the Observatory on 25th September. J.Morris on behalf of all the Volunteers expressed his regret that Tom was leaving, and thanked him for his willingness to teach new volunteers and for his company over the years since the Volunteers started.

G.Lowe stated that Brett Turner would be giving a talk on Mars at the next meeting.

B.Harris reported that K.Kotze and Dr A.Williams would be absent from the next meeting due to involvement with the Solar Powered Car race starting from Darwin.

There being no further General Business the meeting closed at 7.32pm

2003/2004 TRAINING NIGHTS SCHEDULE

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This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated.
Jamie Biggs. Govt Astronomer

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http://www.wa.gov.au/perthobs/hpc5mn03.htm

SKY EVENTS FOR NOVEMBER

All Month - Time travel 2.2 million years into the past by finding the Andromeda Galaxy (evening). The Andromeda Galaxy is the furthest object that can be easily seen with the unaided eye from a dark sky location in the Southern Hemisphere.
2nd - 4th - Moon passes Mars (evening sky).
9th - Full Moon. Avoid nights around this date for star parties.
13th - 16th - Moon passes Saturn, and the stars Castor and Pollux (the brightest stars in the constellation Gemini The Twins) (morning sky).
17th - 19th - The Moon passes Regulus (the brightest star in Leo The Lion) (morning sky).
18th - 20th - Moon passes Jupiter (morning sky).
24th - Partial Solar Eclipse on the morning of November visible from all Australian capital cities.
http://www.ozskywatch.com/amaz/space/skyevent/2003/summary.html

NOVEMBER 2003 METEOR SHOWERS

November has two major meteor showers, the Taurids and the Leonids.
The Taurids peak November 4th-7th, but some may be seen anytime from October 20th through the end of November. The Taurids have a peak rate of 12 meteors per hour, or about one every five minutes on average.

The Leonids, is probably the most famous meteor shower of all. In 2003 the Leonids will have returned to a more normal shower rather than the storms we've seen in the last few years. This shower is the result of the Earth's passage through the dust and debris left by the comet 55P/Tempel-Tuttle.

Comet 55P/Tempel-Tuttle returns to the inner solar system every 33 years. Each time it passes through our part of the solar system, it leaves a trail of dust along its path. These small grains of dust are what become such bright and beautiful meteors in our skies.

Unfortunately the bright Moon will obscure the fainter meteors for us in 2003, but it's still worth giving the Leonids a chance.

Comet 55P/Tempel-Tuttle: History and details about the 1998 Apparition Comet Tempel-Tuttle was "discovered" independently by William Tempel in December 1865 and by Horace Tuttle in January 1866. After this apparition, calculations showed that the comet was in an elliptic orbit with a 33-year period. This information was then used to prove that Tempel-Tuttle was the same comet that had been observed in the year 1366 and again in 1699. The orbit determination was also used to show that T-T was associated with the Leonid meteor shower that occurs every year in November.

Even though astronomers searched for it in 1899 and again in 1932, Tempel-Tuttle was not seen again until 1965, when it was observed as a faint, 16th magnitude object.

http://www.lowell.edu/users/farnham/tt/tthist.html

LECTURE ON BLACK HOLES, GAMMA-RAY BURSTS AND GRAVITATIONAL WAVES

Professor Maurice van Putten
LIGO Research Group MIT
On the 2nd of July 1967, the US military satellites detected a flash of mysterious gamma rays coming from space. Despite looking for the radiation produced by the explosion of thermo-nuclear bombs, the military had discovered what are now known as gamma-ray bursts (GRBs).

Shining as brightly as a million trillion suns yet seldom lasting even one minute, GRBs were a great astronomical mystery only recently solved when they were conclusively shown to be linked to cataclysmic explosions called supernovae that mark the deaths of very massive stars. Since GRBs mark the creation of a new-born black hole, GRBs are also predicted to be strong sources of gravitational waves, or ripples in the fabric of space-time. The detection of gravitational waves associated with GRBs will open a new window to probe the formation of possibly the most exotic object in the Universe, a black hole.

Professor Maurice van Putten has been working in the field of high energy astrophysics since 1992. He has held research positions at Caltech, Cornell University and is currently assistant Professor of mathematics at MIT. He is an expert on modelling the emissions from rotating black holes and has published his research in prestigious journals such as Science and Physical Review Letters.

6 PM - THURS
23 OCTOBER 2003
ROSS LECTURE THEATRE,
SCHOOL OF PHYSICS
FAIRWAY ENTRANCE NO.2
UWA

For further information, or a PDF version of the flyer for this public
lecture please contact Katrina on Ph 9360 2865 or
http://wwwphys.murdoch.edu.au/waaip
Contributor: Giuseppe L.A. Coletti (Joseph).

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Lyall Bell
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Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake
Trevor Dunn
David Emrich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
Nigel Healy
Bert Hollebon
Karen Kotze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Bob Taylor
Patricia Turner
Elaine Walker
Sandra Walker
Matt Zengerer

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Rick Tonello	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Mark Appelhof	Cleaner

POVG VOLUNTEERS

Trevor Dunn	POVG Inc, Chairperson
Karen Koltze	POVG Inc, Vice Chair
Bob Taylor	POVG Inc, Secretary
Bevan Harris	POVG Inc, Treasurer and newsgroup moderator (contact bevan on ngc2070@bigpond.com)

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pix simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

Perth Observatory Volunteers Group

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

Subject: IAUC 8236: C/2003 V1; 2003jh; 2003jg
Date: Thu, 6 Nov 2003 16:16:28 -0500 (EST)
From: IAUC mailing list <quai@cfa.harvard.edu>
To: astro@pd.uwa.edu.au

Circular No. 8236

Central Bureau for Astronomical Telegrams
INTERNATIONAL ASTRONOMICAL UNION
Mailstop 18, Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.
IAUSUBS@CFA.HARVARD.EDU or FAX 617-495-7231 (subscriptions)
CBAT@CFA.HARVARD.EDU (science)
URL http://cfa-www.harvard.edu/iau/cbat.html ISSN 0081-0304
Phone 617-495-7440/7244/7444 (for emergency use only)

COMET C/2003 V1 (LINEAR)

A. Milner, Lincoln Laboratory, Massachusetts Institute of Technology, reports the LINEAR discovery of a comet with a tail in p.a. 330 deg (discovery observation below). Following posting on the NEOCP, other CCD observers recognized the object as a comet, reporting additional physical data: Nov. 5.2 UT, 12" coma (mag 16.5) and 40" tail (A. Knoefel, Essen, Germany, 0.32-m reflector); Nov. 5.5, 7" coma (mag 16.5) with a broad tail a little more than 70" long spanning p.a. 290-310 deg, including two or three streamers, the brightest of which is 30" long in p.a. 295 deg (J. Young, Table Mtn., CA, 0.6-m reflector); Nov. 5.5, coma diameter about 10", with 10" tail in p.a. 310 deg (P. R. Holvorcem and M. Schwartz, Nogales, AZ, 0.81-m reflector; three 180-s exposures); Nov. 6.4, soft coma of diameter 6", broad tail 9" long in p.a. 310 deg (J. E. McGaha, Tucson, AZ, 0.30-m reflector).

2003 UT	R.A. (2000)	Decl.	Mag.
Nov. 4.47409	10 20 35.08	+41 11 33.4	18.1

The available astrometry, the following preliminary parabolic orbital elements, and an ephemeris appear on MPEC 2003-V28.

T = 2003 Apr. 7.074 TT	Peri. =	8.632	
	Node =	18.733	2000.0
q = 1.51524 AU	Incl. =	28.888	

SUPERNOVA 2003jh IN MCG -02-11-30

Further to IAUC 8232, M. Moore and W. Li report the LOSS discovery, on KAIT images taken on Oct. 29.4 (mag about 17.8) and 30.4 UT (mag about 17.9), of an apparent supernova located at R.A. = 4h16m37s.30, Decl. = -12o23'32".9 (equinox 2000.0), which is 12".4 west and 21".9 north of the nucleus of MCG -02-11-30. A KAIT image taken on Oct. 22.4 showed nothing at this position (limiting mag about 19.0).

SUPERNOVA 2003jg IN NGC 2997

Further to IAUC 8235, J. Biggs corrects the offset of SN 2003jg to 11" west and 6" north of the center of NGC 2997. L. A. G. Monard, Pretoria, S. Africa, reports SN 2000jg at R.A. = 9h45m38s.40, Decl. = -31o11'19".9 (equinox 2000.0), supplying the following unfiltered CCD magnitudes: Sept. 2.141 UT, [17.0; 27.125, [17.0; Oct. 30.097, 16.5; 31.087, 16.8.

2003 November 6 (8236) Daniel W. E. Green

Subject: IAUC 8235: 2003jg; 2003 QY_90; V838 Mon
Date: Wed, 29 Oct 2003 22:42:06 -0500 (EST)
From: IAUC mailing list <quai@cfa.harvard.edu>
To: astro@pd.uwa.edu.au

Circular No. 8235

Central Bureau for Astronomical Telegrams
INTERNATIONAL ASTRONOMICAL UNION
Mailstop 18, Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.
IAUSUBS@CFA.HARVARD.EDU or FAX 617-495-7231 (subscriptions)
CBAT@CFA.HARVARD.EDU (science)
URL http://cfa-www.harvard.edu/iau/cbat.html ISSN 0081-0304
Phone 617-495-7440/7244/7444 (for emergency use only)

SUPERNOVA 2003jg IN NGC 2997

R. Martin, Perth Observatory, reports the discovery, on CCD images taken on Oct. 24.800 and 28.752 UT with the 0.61-m Perth/Lowell Automated Telescope in the course of the Perth Automated Supernova Search, of an apparent supernova (red mag 17) located in NGC 2997. J. Biggs, Perth Observatory, writes that three unfiltered exposures taken with the 25-cm Mike Candy Telescope around Oct. 29.778 show the new object (R = 17 +/- 1) at the following position: R.A. = 9h45m37s.91 +/- 0".3, Decl. = -31o11'21".0 +/- 1".0 (equinox 2000.0), which is approximately 11" east and 6" north of the galactic nucleus. Martin adds that nothing is visible at this location on an image taken on Sept. 25.876 (limiting mag 19), but the object does appear, just above the noise threshold, in an image taken on Oct. 5.850.

2003 QY_90

J. L. Elliot, Massachusetts Institute of Technology (MIT), reports that Sloan-r'-band observations, obtained by S. D. Kern (MIT) at the 6.5-m Clay telescope (+ MagIC) on Oct. 23 UT in about 0".5 seeing, reveal highly elongated images of 2003 QY_90 (cf. MPEC 2003-Q58). The consistency of the images over the 1.9-hr interval between the first and last frames rules out a blend with a background field object. Interpreting each elongated image as a pair of unresolved sources, analysis by K. B. Clancy (MIT), Kern, and Elliot implies the following properties: both objects are nearly identical in brightness [Delta(r') = 0.1 +/- 0.2]; the separation of the pair is 0".34 +/- 0".02; and the line between the two putative bodies has an approximate position angle of 129 +/- 5 deg. Additional photometric and astrometric observations of 2003 QY_90 are strongly encouraged.

V838 MONOCEROTIS

M. Tapia, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico; and P. Persi, Istituto Astrofisica Spaziale e Fisica Cosmica, report the following magnitudes observed with the 2.1-m telescope (+ mid-infrared camera CID) at San Pedro Martir on Oct. 5.5 UT: [8.7 microns] = 0.20, [9.7 microns] = -0.22, [12.5 microns] = -0.83, [19 microns] = -1.37. The object is cooler and has brightened at these wavelengths by about 2 magnitudes since 2002 Sept. (cf. IAUC 7976) when observed with the same instrument.

2003 October 29 (8235) Daniel W. E. Green

DECEMBER 2003

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

A VERY MERRY CHRISTMAS AND A HAPPY NEW YEAR TO ALL STAFF AND VOLUNTEERS AT PERTH OBSERVATORY

AURORA SIGHTINGS IN PERTH

Hi all. Yes I can confirm Dave Emrich's observations, as there have been calls to the Obs this morning about the 3am aurora.

Vic Levis has photos, which he will display at the Monday vollie meetings. Also sightings from Pingelly (Trvor Keates at the Pingelly Obs) and from...... Mount Magnet can you believe - at -28 latitude.

The phenomena was predicted, as follows.....
A coronal mass ejection swept past Earth during the early hours of Nov. 20th and sparked bright auroras over northern parts of the United States. At the time of this writing (1600 UT or 11:00 a.m. EST) a strong geomagnetic storm is in progress.

The interplanetary magnetic field near Earth has tilted sharply south--a condition which promotes geo-magnetic activity. If this condition persists, auroras are possible at low latitudes tonight.
The source of this space weather is sunspot 484—one of the trio of big sunspots that caused intense solar storms last month. Indeed all three of those active regions are back on the Earth-facing side of the sun, so more solar activity is possible in the days ahead.

Visit Spaceweather.com for more information and pictures of today's auroras.

The aurora was also seen from 170km N of Newman - -22S !!

Astronomy is Looking up !!

Peter Birch

VOLLIE OF THE MONTH - JEANNE BELL

Jeanne suggested that it would be a good idea if we crank up the Vollie Profiles which was attempted before but never quite got off the ground. However, she has kindly included some of her details and interests. If you'd like to feature in this section please send any information with a photo (jpeg format) of yourself, to me for inclusion in our future newsletters.

Thanks Jeanne, looking forward to the rest of the vollie contributions. Ed.

NAME: Jeanne BELL
STAR SIGN: Scorpio
DAY JOB: Runs a commercial construction company with her husband

FAMILY:
Husband - Ken, Daughter - Sarah (16), son - Cale (14)

HOBBIES: Cooking, bushwalking, reading, astronomy, fishing, tennis & travel

LIVES IN: Claremont
EMAIL: kjscbell@cygnus.uwa.edu

OBSERVATORY:
Joined as a night tour volunteer in the first intake but her main role now is the collation of vollies' time sheets. Information collected is submitted to CALM once a quarter.

OTHER INTERESTS: Conducts school tours of Bethesda hospital, works for Choice magazine and runs a community service programme for Year 10 boys at Christ Church Grammar School.

NORTHERN VS SOUTHERN HEMISPHERE BIAS RAISES BILKI'S IRE

The northern hemisphere bias to astronomy textbooks has always bugged me. In fact, many of the geospatial reference books that I use are also significantly biased towards the northern hemisphere.

Being the geographically inquisitive fellow that I am, I decided to check the relative populations of the Nth vs. Sth hemispheres to see if that might explain the bias... and it sure does! The total population of the northern hemisphere is around 5 billion, whereas the southern hemisphere can only muster a mere 700 million people. So, there are over 7 times the number of people above the equator than below it. I guess that if one in every 7 astronomy books works for the southern hemisphere, we should consider ourselves fortunate!

The funny thing is, Australia is a real powerhouse of research and ingenuity, especially in the mining/geospatial industry where I work. Many of the world's premier geospatial software packages (including the one that I work for!) originate right here in Perth, and yet others originate in other Australian cities. Plus, much of the modern mining industry's technology was pioneered right here in Oz. Not bad for a country with only 20 million people!

Southern Hemisphere astronomy has been going for a lot longer than you might think.

Most texts suggest that Classical astronomy (i.e. Northern Hemisphere astronomy) started anywhere between 10,000 and 4,000 BC (depending on who you read), but that the first written texts didn't appear until around 3,000 BC. The constellations as we know them (more or less) were developed around 2,500 BC.

However, Aboriginal Dreamtime legends featuring the night sky were developed around 40,000 years ago. Most of the 'Aboriginal Constellation of the Month' articles that I've been quoting in the Vollie newsletter originated many tens of thousands of years ago. In addition to their Dreamtime legends, the aborigines were also using the appearance of certain stars or constellations in the evening sky to mark calendrical events such as initiations or the coming into season of a particular food. What amazes me is how often the Aboriginal mythology seems to match the accepted Classical mythology for the same constellation. For example, the constellation we know as Orion was known to some Aborigines as Jarn, who was also a hunter.

I suspect that most early Southern Hemisphere civilisations (like the Polynesians, Maoris, etc.) had also developed similar astronomical folk lore back then, too. Unfortunately for us, the legends were passed down by word of mouth, and so there's little or no written history. It's only been in recent times that some workers have taken the time to learn and document the ancient myths before they're lost to us forever.

Frank Bilki

POVG MEETING - MINUTES

Minutes of Meeting
October 20th 2003-10-29

Meeting Commenced at 7.10

Present.T.Beston. E.Walker. B.Hollebon. L.Bell. L.Martin. J.Morris. D.Emrich. T.Turner. C.Bell. G.Lowe. J.Biggs. M.Haslam. T.Smith. T.Dunn. D.Alderton. P.Birch. F.Bilki. L.Robinson.

Apologies. B.Harris. K.Kotze. A.Williams. A.McNaughton. J.Bell.

Minutes of the Previous Meeting
Agreed as a true and correct record by L.Martin seconded by T.Beston

Treasurer's Report.
No change from the previous meeting

General Business
TDunn welcomed B.Turner C.Bell and T.Smith to the meeting.

F.Bilki reported on contact with the N.Z Volunteer Group and and the arrival of their group newsletters.

G.Lowe went through the new technique required for shutting down the 16 inch Telescope.

There being no further General Business the meeting closed at 7.16

2003/2004 TRAINING NIGHTS SCHEDULE

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated.
Jamie Biggs. Govt Astronomer

2003	2004
May 26	Jan 19
Jun 30	Feb 23
Jul 28	Mar 15
Aug 25	Apr 19
Sep 22	May 17
Oct 20	Jun 14
Nov 24	Jul 12
	Aug 9

PHASES OF THE MOON FOR 2003 (WA TIME)

New Moon		**First Quarter**		**Full Moon**		**Last Quarter**	
Jan 3	04:23	Jan 10	21:15	Jan 18	18:47	Jan 25	16:33
Feb 11	08:48	Feb 9	19:11	Feb 17	07:51	Feb 24	00:46
Mar 31	00:35	Mar 11	15:15	Mar 18	18:34	Mar 25	09:51
Apr 2	03:18	Apr 10	07:40	Apr 17	03:35	Apr 23	20:18
May 01	20:15	May 09	19:53	May 16	11:36	May 23	08:30
May 31	12:20	Jun 08	04:27	Jun 14	19:16	Jun 21	22:45
Jun 30	02:38	Jul 07	10:32	Jul 14	03:21	Jul 21	15:01
Jul 29	14:53	Aug 05	15:27	Aug 12	12:48	Aug 20	08:48
Aug 28	01:26	Sep 03	20:34	Sep 11	00:36	Sep 19	03:03
Sep 26	11:09	Oct 03	03:09	Oct 10	15:27	Oct 18	20:31
Oct 25	20:50	Nov 01	12:25	Nov 09	09:13	Nov 17	12:15
Nov 24	06:59	**Dec 01**	**01:16**	**Dec 09**	**04:37**	**Dec 17**	**01:42**
Dec 23	**17:43**	Dec 30	18:03				

http://www.wa.gov.au/perthobs/hpc5mn03.htm

SKY EVENTS FOR DECEMBER

Meteor Showers.
Phoenicids: Nov 28 to Dec 9;
Geminids: Dec 7 to Dec 17.Best observations are from mid-night to dawn, looking eastwards.

Comets.
Comet 22P/Kopff
Comet C/2001 HT 50 (Linear-Neat)
Comet P/1992 Q1 (Brewington)
COMET NEAT (C/2002 V1)
COMET KUDO-FUJIKAWA (C/2002 X5)

Special Events.
The Mid-Summer Solstice
The Mid-Summer Solstice will occur at 1500 on Monday December 22. This is when the Sun 'appears' to stop moving southward and begins its journey back towards the Celestial Equator. At this time, we, in the southern hemisphere, experience our LONGEST day and SHORTEST night. This effect is caused by the 23 degree tilt of the Earth's axis.

PERTH OBSERVATORY VOLUNTEERS GROUP INC.

VOLUNTEER MEMBER LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake
Trevor Dunn
David Emrich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
Nigel Healy
Bert Hollebon
Karen Koltze
Erin Lalor
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moderator (contact bevan on ngc2070@bigpond.com)

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POVG
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VollieNews

JANUARY 2004

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

GOODBYE FROM THE VOLLIEGROUP CHAIR

To Jamie and all the Observatory staff, and to all our Vollie Group members, may I wish each and every one of you a belated 'Happy New Year'.

I'm sorry to have been out of communication over recent times - both about my personal situation and about the bone marrow donation I've recently been involved in - and I hope this will serve to bring you up to speed with each.

Firstly, the more inspirational issue. Some of you will know that I was recently tissue matched with a young child with a terminal bone marrow disorder, and asked to donate some of my own.

The procedure happened in late November and the news to date is that signs of rejection in the child have not so far appeared. They are cautiously optimistic that my marrow may have begun the process of becoming engrafted already, and they have sent the little bloke home to be nursed to avoid him picking up any infection from remaining in hospital.

He's not out of the woods yet, but it's looking reasonably hopeful and positive for him at the moment. It will be February before they can determine whether he's fully cured, so please keep some positive vibes happening for him until then. For those of you who were aware of this event - thanks for your interest and concern.

May I even be so bold as to suggest that some of you might like to call in at the Red Cross Blood Bank in Wellington Street next time you're in town and get yourself on the bone marrow register...? I had been on it for maybe 15 years before I 'got the call', and it's now made a significant difference to one little bloke's prospects of having a life.

And secondly, my resignation as Chairman of our Vollie Group. Due to personal circumstances I am about to return to the UK to live for the foreseeable future, and accordingly the January 19 meeting will be my last as a member.

Thank you Jamie, for your kind comments in your email advising the group of this; and thank you to all of you for your generous support and participation in the activities that we've jointly undertaken over the years since we got started in late 1996.

I've thoroughly enjoyed being a part of such an illustrious, knowledgeable and good-humoured group, and not being up there with you at the telescopes on a cool, clear night will be a big gap in my life. I wish you all the very best for your involvement in the Vollie Group's future adventures, and my thanks to all of you for your friendship and for being such good company on so many occasions.

Kind regards to you all and goodbye.

SUMMER LECTURE IN FEBRUARY PROMISES TO BE A GOOD ONE

SUMMER LECTURE.
PROF RAY NORRIS
OF ATNF, SYDNEY,

Although the topic is yet to be announced, Jamie has seem him 'in action' and says he delivers a great lecture.

Date: Sun 15 Feb, 8pm. Perth Observatory.

Tickets to the public are just $5.00.

Please invite or promote other to attend.

ASTRO NEWS

NASA CANCELS FINAL HUBBLE TELESCOPE SERVICING MISSION

A final planned shuttle mission to service and upgrade the Hubble Space Telescope, one of the most scientifically productive spacecraft ever launched, has been cancelled, primarily because of post-Columbia safety concerns and a new directive to retire the shuttle by 2010, NASA officials said today.
http://spaceflightnow.com/news/n0401/16hubblesm4/

COMET ORBITER AND LANDER SET FOR RESCHEDULED VOYAGE

Europe's long-awaited Rosetta space probe is being readied for a second time to begin its ambitious mission that will see it embark on a decade-long journey through the solar system before reaching its mysterious icy objective.
http://spaceflightnow.com/news/n0401/15rosetta/

SCIENTISTS FIND 'SPITTING STAR' IMITATES BLACK HOLE

A neutron star has been seen spitting out a jet of matter at very close to the speed of light. The discovery challenges the idea that only black holes can create the conditions needed to accelerate jets of particles to extreme speeds.
http://spaceflightnow.com/news/n0401/15spitting/

A FAILED STAR IS BORN

In cosmic circles, brown dwarfs are something of a flop. Too big to be considered true planets, yet not massive enough to be stars, these free-floating celestial bodies are, in fact, sometimes referred to as failed stars. But do they really form as stars do — from collapsing clouds of gas — or are their origins completely different?
http://spaceflightnow.com/news/n0401/15failed stars/

SIX-WHEELING ON MARS: SPIRIT ROVER DRIVES OFF LANDER

The Mars Spirit rover successfully drove onto the surface of the Red Planet. The rover is ready to embark on its three-month expedition to explore the Gusev Crater for evidence of past water.
http://spaceflightnow.com/mars/mera/status.html

HOT AND COLD GAS RAGE IN BETELGEUSE'S ATMOSPHERE

A team of astronomers have announced that Hubble Space Telescope observations of a nearby supergiant star directly show hot gas escaping its boiling atmosphere at a larger distance than from any other star. The expelled hot gas somehow survives the cold and harsh conditions in the star's bloated upper atmosphere.
http://spaceflightnow.com/news/n0401/15atmosphere/

STORMY CLOUD OF STAR BIRTH GLOWS IN NEW SPITZER IMAGE

A dusty stellar nursery shines brightly in a new image from NASA's Spitzer Space Telescope, formerly known as the Space Infrared Telescope Facility. Spitzer's heat-sensing "infrared eyes" have pierced the veiled core of the Tarantula Nebula to provide an unprecedented peek at massive newborn stars.
http://spaceflightnow.com/news/n0401/15sstimage/

ROCK FRAGMENTATION AT ROVER SITE POSSIBLY RESULT OF WATER

The first 360-degree panorama taken by the Spirit rover's main camera system provides a spectacular view of Gusev Crater's cracked and churned-up floor, including an abundance of small, cracked rocks and fragments that could be the result of water-driven erosion in the distant past, researchers said Monday.
http://spaceflightnow.com/mars/mera/040112science.html

ASTRONOMERS SAY STAR MAY BE BIGGEST, BRIGHTEST YET OBSERVED

A University of Florida-led team of astronomers may have discovered the brightest star yet observed in the universe, a fiery behemoth that could be as much as much as seven times brighter than the current record holder.
http://spaceflightnow.com/news/n0401/12brightest-star/

JETS SPOUT FAR CLOSER TO BLACK HOLE THAN THOUGHT

Scientists at the Massachusetts Institute of Technology, taking advantage of multiple unique views of black hole particle jet over the course of a year with NASA's Chandra X-ray Observatory, have assembled a "picture" of the region that has revealed several key discoveries.
http://spaceflightnow.com/news/n0401/12blackhole-jet/

CHIAO REPLACES MCARTHUR AS NEXT STATION COMMANDER

Veteran NASA astronaut Leroy Chiao will replace Bill McArthur as the commander of Expedition 9, the next mission aboard the International Space Station. The change in crew assignment is a result of a temporary medical issue related to McArthur's qualification for this long duration flight.
http://spaceflightnow.com/news/n0401/12exp9crew/

CHANDRA LOCATES PLANETARY ORE IN COLLIDING GALAXIES

NASA's Chandra X-ray Observatory has discovered rich deposits of neon, magnesium and silicon in a pair of colliding galaxies known as The Antennae. When the clouds containing these elements cool, an exceptionally high number of stars with planets should form. These results may foreshadow the fate of our Milky Way and its future collision with the Andromeda Galaxy.
http://spaceflightnow.com/news/n0401/07collision/

TOO FAST, TOO FURIOUS: A GALAXY'S FATAL PLUNGE

Trailing 200,000-light-year-long streamers of seething gas, a galaxy that was once like our Milky Way is being shredded as it plunges at 4.5 million miles per hour through the heart of a distant cluster of galaxies. In this unusually violent collision with ambient cluster gas, the galaxy is stripped down to its skeletal spiral arms as it is eviscerated of fresh hydrogen for making new stars.
http://spaceflightnow.com/news/n0401/07plunge/

BORAX MINERALS MAY HAVE BEEN KEY TO START EARTH LIFE

Astrobiologists, supported by NASA, have announced a major advance in understanding how life may have originated on Earth billions of years ago.
http://spaceflightnow.com/news/n0401/08borax/

PROBE INTERCEPTS COMET TO GATHER SAMPLES

NASA's Stardust spacecraft successfully survived its risky close approach to the icy heart of Comet Wild 2 today on a first-of-its-kind quest to collect samples for return to Earth.
http://spaceflightnow.com/stardust/status.html

2003: A YEAR SCARRED BY COLUMBIA TRAGEDY

The past 12 months have seen many historic and tragic moments in space exploration. From the obvious impact of the loss of space shuttle ColumbiaFebruary 1 to the resounding success of the maiden Chinese manned spaceflight in October, space enthusiasts and industry insiders alike will have a lot to remember from 2003.
http://spaceflightnow.com/news/n0401/01yearinreview/

BOEING GETS $1 BILLION SPACE STATION CONTRACT EXTENSION

NASA has extended a primary contract for the International Space Station for On-Orbit Acceptance and Vehicle Sustaining services to The Boeing Company. The basic period of the cost-plus-award-fee contract extension is two years and nine months with an estimated value as much as $1 billion.
http://spaceflightnow.com/news/n0401/01boeingiss/

ION ENGINE PASSES TEST

A new ion propulsion engine design, one of several candidate propulsion technologies under study by NASA's Project Prometheus for possible use on the proposed Jupiter Icy Moons Orbiter mission, has been successfully tested by a team of engineers at NASA's Jet Propulsion Laboratory.
http://spaceflightnow.com/news/n0312/23jimoengine/

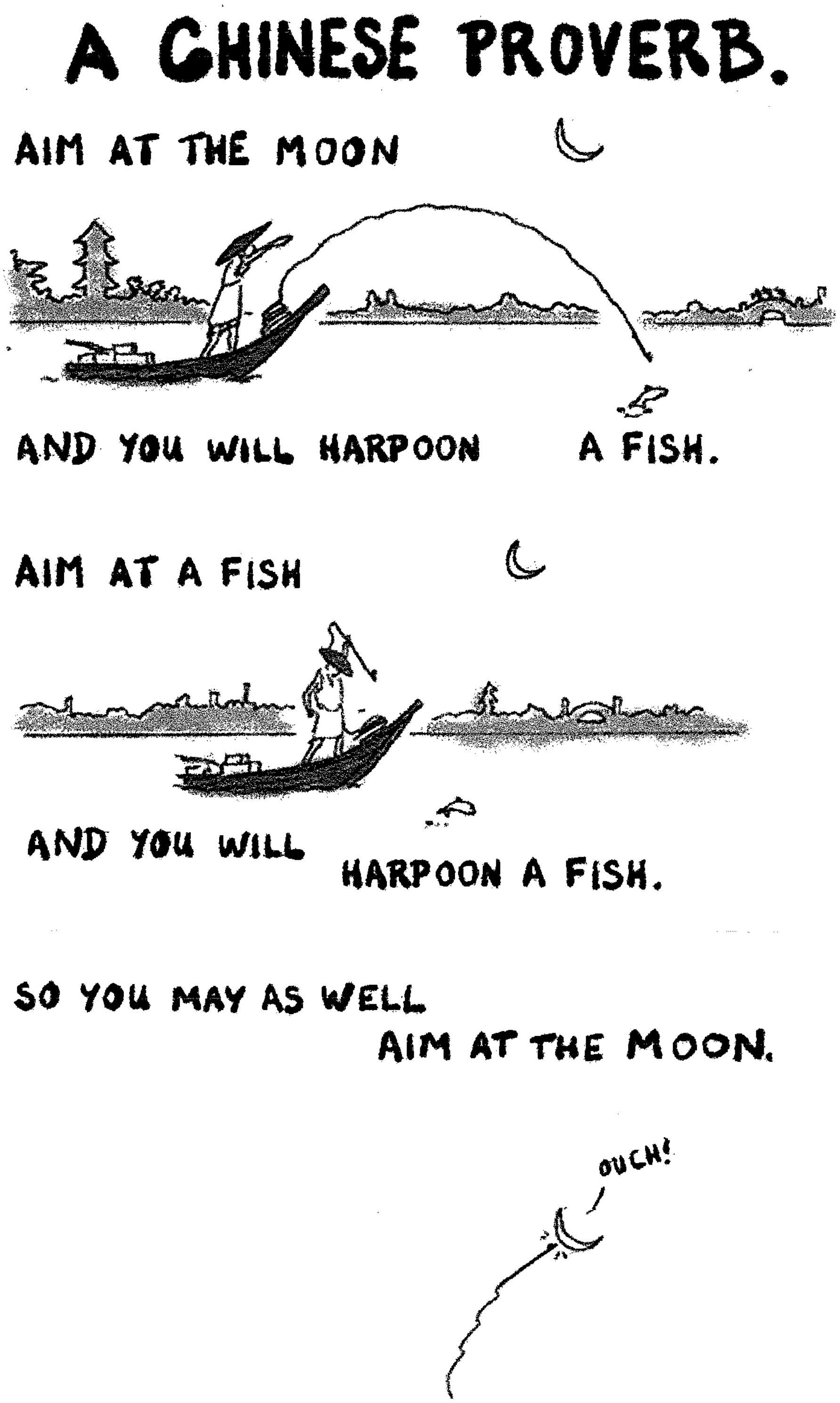
SHARP IMAGES OF SOLAR STORMS

As last October's solar flares blossomed into a coronal mass ejections, scientists at the National Solar Observatory used a new set of instruments to record the sharpest-ever images of the heart of the storms.
http://spaceflightnow.com/news/n0312/23solarstorm/

BUSH UNVEILS NEW SPACE INITIATIVE

President Bush ordered a sharp change of course for NASA Wednesday, directing the agency to complete the space station and retire the shuttle by 2010 and to begin development of a new spacecraft to carry astronauts back to the moon by the middle of the next decade.
http://spaceflightnow.com/news/n0401/14spacepolicy/

Cartoon by Chris Madden web site.
http://www.goma.demon.co.uk/



LARGE IMPACTS AND FAUNA EXTINCTION

The processes following the impacts of a large extraterrestrial object in relation to extinction have become a little better understood through computer modelling and simulation completed in the past year.

A question has existed for a number of years in that if the Chixulub impact was as severe as we think, how did any terrestrial life survive. If the 10-km diameter body that produced the 180 km crater while ejecting 10000 cubic kilometres of rock generated catastrophic and near-simultaneous firestorms around the world, how did any life survive.

The background to this is that charcoal and ash remains have been found at many places around Earth on the K/T boundary (the boundary between Cretaceous and Tertiary-aged rocks respectively below and just before or above and after the impact), along with the tell-tale iridium geochemical anomaly suggestive of a meteoritic or asteroidal source.

Researchers at Chicago and Boulder have now developed impact computer simulation programs initially based on researching the images from 60-km asteroid Ida. Ida is covered with craters, but also shows a blanketing of "powdery" dust and particles, interpreted to have been derived from pulverising of colliding objects at the time of the impacts-that caused the craters.
Scaling-up the situation and feeding in known information in relation to the Chixulub impact, the modelling has produced a very curious effect.

On impact, large bodies eject molten rock at high velocity and at trajectories ranging from low to very high. Large molten rock particles settle near to the impact, but smaller ones, and those with high-angle trajectories can go out to huge distances before being decelerated and brought back by Earth's gravity (some are modelled to go half-way to the Moon).

Being molten particles, those that settle into the upper atmosphere within hours and possibly within days, are still emitting infra-red heat. They can have densities to produce enough heat at the Earth's surface to ignite vegetation. However, it had previously been assumed that they fall fairly evenly spread around the Earth.

The new modelling, however, shows a different pattern. Largest quantities fall near to the impact site to form a node of firestorms within several to a few thousand kilometres of the impact site.

However, because of the nature of the trajectories, many of the higher-rising particles actually fall on the opposite side of the Earth, producing a second node of firestorms. At the time of Chixulub, that was on the then-island of India in the middle of the Indian Ocean.

Two main fall-concentrations form, a near one around the impact site and a second on the far side of Earth. The time taken for the higher-rising particles to fall can be hours to days, especially for those at the second node. The second node of fire-storms will be created by the fastest-falling particles possibly after an hour or two of the actual impact.

For several hours after that initial fall though, the Earth is rotating under the fall-centre. Thence the primary firestorm node passes across the precursor to the Pacific Ocean and then eastern and southern Asia, and the secondary node into Africa and then into South America.

The consequence is to leave far northern North America and northern Europe with somewhat lesser effects from the impact.

Following this modelling researchers have now found that populations of plant spores taken from many sites around the World actually correlate with the computer modelling, adding plausibility to the theory. The mere fact that sufficient higher forms of-life survived to allow mammals to evolve and dominate, and leading to humans has now, of course, led to the generation of another phase of activity that some people will argue could rival the impact of f Chixulub!

The papers were published in the Canadian Journal of Earth Sciences, Nature and Science, and a popular science article in New Scientist.

Mike Freeman

NASA SPACECRAFT MAKES GREAT CATCH

Comet Wild 2 is shown in this image taken by the Stardust navigation camera during the spacecraft's closest approach to the comet on January 2. The image was taken within a distance of 500 kilometres (about 311 miles) of the comet's nucleus with a 10-millisecond exposure. A total of 72 images were taken of the comet during the flyby.

NASA's first dedicated sample return mission to a comet, passed a huge milestone by successfully navigating through the particle and gas-laden coma around comet Wild 2 (pronounced "Vilt-2").

During the hazardous traverse, the spacecraft flew within 240 kilometres (149 miles) of the comet, catching samples of comet particles and scoring detailed pictures of Wild 2's pockmarked surface.

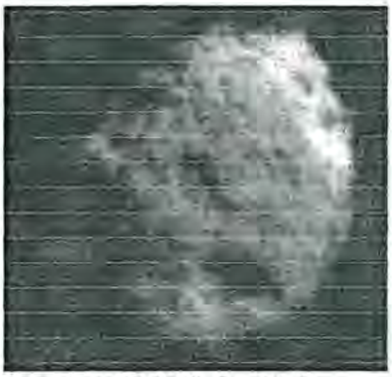


Photo Credits: NASA/JPL. Team Stardust.

SKY EVENTS FOR JANUARY 2004

Saturday, January 3
NASA Mars rover Spirit lands on that planet tonight.

Sunday, January 4
Quadrantid meteor shower peaks. Jupiter is stationary, 10 a.m. EST.

Tuesday, January 6
The Moon passes 5° north of Saturn, 7 p.m. EST.

Friday, January 9
Asteroid Ceres is at opposition, 9 a.m. EST.

Monday, January 12
The Moon passes 3° north of Jupiter, 6 a.m. EST.
Asteroid Hebe is at opposition, 6 p.m. EST.

Saturday, January 24-25
NASA Mars rover Opportunity lands on that planet just after Midnight (12:05 a.m. Jan. 25).

SKY EVENTS FOR FEBRUARY 2004

Monday, February 2
Neptune is in conjunction with the Sun, 4 a.m. EST.
The Moon passes 4° north of Saturn, 11 p.m. EST.

UPCOMING EVENTS FOR 2004

January 2004 will be ideal for viewing Saturn during its closest approach for 35 years.

May 2004 is a very busy month, not only is the Moon, Venus, Mars, Jupiter and Saturn together in the night sky, but: There will be a total eclipse of the Moon on 5 May, 2004.

Comet 2001 Q4 NEAT should become a naked eye comet (but not spectacular) in the Southern Hemisphere in May 2004.

Comet 2002 T7 should also become a naked eye comet, possibly spectacular, in the Southern Hemisphere at around the same time as Comet 2001 Q4 NEAT.

Venus will transit the Sun on June 8 2004.

There will be a Blue Moon on August 30th, 2004.

The Moon will pass in front of Venus on November 10, 2004.

PLANETS:

Mercury Returns to the morning sky in January. By the 9th, it is two handspans above the south eastern horizon, half an hour before sunrise. By the 17th, it is three handspans above the south eastern horizon, half an hour before sunrise. On the morning of the 20th the crescent Moon will be four fingerwidths above Mercury. By the end of the Month, Mercury is two handspans above the south-eastern horizon, and half an hour before sunrise

Venus is prominent in the evening sky. On the 1st Venus is three handspans above the western horizon, half an hour after sunset. On the evenings of the 24th and 25th the crescent Moon will be a handspan above, and below Venus respectively. By the end of the month Venus will remain three handspans above the horizon half an hour after sunset.

Earth was at the perihelion, it's closest approach to the Sun, on the 5th.

Mars is fading rapidly, and almost featureless in most small telescopes, despite being distinctly gibbous. Mars is visible in the western evening sky, and is the brightest object in the western sky apart from Venus. On the evening of the 28th the Moon will be two fingerwidths from from Mars.

Jupiter rises around midnight at the beginning of this month, and by the end of the month it rises around 10.00pm AEDST. On the 1st Jupiter is the brightest object eight handspans above the northern horizon half an hour before sunrise. On the morning of the 13th the waning Moon will be three fingerwidths below Jupiter. On the 31st Jupiter is the brightest object three handspans above the north-eastern horizon at around midnight.

Saturn is visible high in the evening sky. On the 1st Saturn is the brightest object three handspans above the north-eastern horizon around 10.00 pm AEDST. It is also about two handspans above and to the left of the pair of bright stars Castor and Pollux.

On the 6th and the 7th the Full Moon will be just over a handspan from Saturn. By the end of the month Saturn is high in the northern sky by 10.00 pm AEDST. Saturn is at opposition on the 1st, and Saturns rings are the widest they have been for some time.

This is an excellent time to look at Saturn. http://home.mira.net/%7Ereynella/skywatch/ssky.htm

All descriptions here are based on the view from Melbourne at 10.00 pm AEDST (Australian Eastern Daylight Saving Time) on 1 January and assumes a fairly level horizon.

Starset occurs progressively earlier each day, so these descriptions are valid for 9.00 pm on the 15th and 8.00pm on the 30th.

Readers for Central and Western time zones should see roughly the same views at 10.00 pm ACDST and AWDST.

***Readers in Sydney, Fremantle and Perth should add 3 finger widths to the northern descriptions, and subtract 3 finger widths to the south.**

Facing west, the battered triangle of Capricorn, the Goat, is 3 handspans left of west, almost directly on the horizon. To the right by 3 hand spans and up by two handspans is Aquarius.

6 handspans up from the western horizon and three hand spans to the left is bright Fomalhaut, the main star of Piscis Austrinus, the southern fish.

Further off to the left is the battered cross of Grus the crane.

The faint constellation of Cetus, the whale is just below the zenith stretching from the west to south-west.

The Zenith is dominated by the rambling constellation Erandius, the river, and bright Achenar, alpha Erandius.

Achenar is the 9th brightest star in the sky, and is a blue supergiant. Epsilon erandi is notable for being the 10th closest star to our solar system. A sun-like star, epsilon erandi has recently been discovered to have a dust disk which may indicate the presence of planets.

On the eastern horizon are the constellations of hydra, directly east, and rectangle of Gemini, 6 handspans to the left. The bright stars of Gemini, Castor and Pollux, will not cleat the Horizon until about an hour later

The constellations of Taurus, the bull, Orion the hunter and Canis major, Orions hunting dog are now well above the horizon, and will be magnificent viewing later in the month, when the moon has waned.

Directly east, 8 handspans from the horizon is Canis major. The bright white star is Sirius (alpha Canis Majoris), the brightest star in the sky. The constellation of Canis Majoris has a number of open clusters that are well worth exploring with binoculars, Most of these lie two handspan to the right of Sirius, amongst the V shaped group of stars that marks the tail of Canis major. Below Sirius by two hand spans, and one handspan to the right is M47. This cluster is quite nice in binoculars.

To the left of Sirius by about four handspans is the distinctive saucepan shape of Orions belt. The handle of the saucepan is Orions sword, which contains some good naked eye open clusters, and the final star in the handle hosts the famous Orion nebula, which is visible to the naked eye under clear skies. Directly above the handle of the saucepan is bright Rigel (beta Orionis). Directly below the saucepan is the bright reddish Betelgeuse (alpha Orinonis), a red giant star.

To the left of Orions belt by about 4 handspans is Alderbaran (alpha Tauri), another red giant which forms the base of the V shaped group of stars called the Hyades, which forms the head of Taurus.

Further to the left again is a faint, but pretty, compact cluster of stars called the Peliades (the seven sisters). The Peliades are particularly beautiful through binoculars.

Facing directly north, about three handspans up is Perseus. Six handspans up is the Peliades. The large square of stars that forms Pegasus, the flying horse is six handspans to your left on the north-western horizon.

Andromeda, and the famous Andromeda galaxy, is two handspans below the bottom right hand star of the square, and one hand span to the right, near a faint star. Andromeda is best seen through binoculars or a small telescope on a dark night. However, as Andromeda is so close to the horizon, it may be difficult to see anything.

Looking south, the bright, distinctive alpha and beta Centauri, the so called "pointers", are two handspans from the southern horizon, with alpha being the yellow star which is furthest from the horizon, and beta the blue white star below and to the left. Most of the rest of Centarus, the Centaur, is too close to, or below, the Horizon to be seen properly.

Alpha Centauri is the closest star to our sun at around 4 light years. However, recent measurements with the Hippacaros satellite put the system 300 million kilometres further away than previously thought. Alpha centauri is actually a triple star, consisting of two sunlike stars and a red dwarf, Proxima centauri, which is the closest of the triple stars to earth.

Returning to alpha Centauri, following a line east through the "pointers" brings you to the Southern Cross, one and a half handspans from beta Centauri to beta Crucis, and two handspans above the horizon between the 7 o'clock and 8 o'clock position on a clock. A high definition map of Centaurus and Crux is here.

The Southern Cross is a cross shaped formation with Acrux (alpha Crucis) and gamma Crucis forming the long axis of the cross (pointing down to the south-east, with bright Acrux on the end of the axis away from the horizon). Beta and delta Crucis, forming a nearly horizontal line, form the cross piece of the cross.

Just to the right of Acrux is the coal sack. This dark area against the glow of the milky way represents a large dust cloud and is usually clearly visible in dark skies, but will be hard to see this close to the horizon.

The Jewel box in the Cross is a small open cluster just above Beta Crucis. It is quite beautiful, but requires strong binoculars or a small telescope to see properly, and is unlikely to be good viewing this close to the horizon.

Above and to the left of the Southern Cross is Carina (the keel of the former constellation Argo Navis). It is now far enough from the horizon to appreciate its many faint objects. Looking almost anywhere in the area of Carina will reveal an interesting cluster or star formation.

However, the area between the Southern Cross and the false cross (which is just above the south-eastern horizon), is particularly rich. Here you will find the "Southern Peliades" surrounding the tail star (Theta Carina) of a prominent kite shaped group of stars, with theta Carina two handspans up, and one handspan to the left of Acrux.

Four fingerwidths below the Southern Peliades are two rich open clusters, and the barely visible star Eta Carina. Eta Carina's spectacular nebula is only dimly seen in binoculars.

Two handspans to the left and four handspans up from the Southern Cross is the False Cross, seven handspans from the southern horizon.

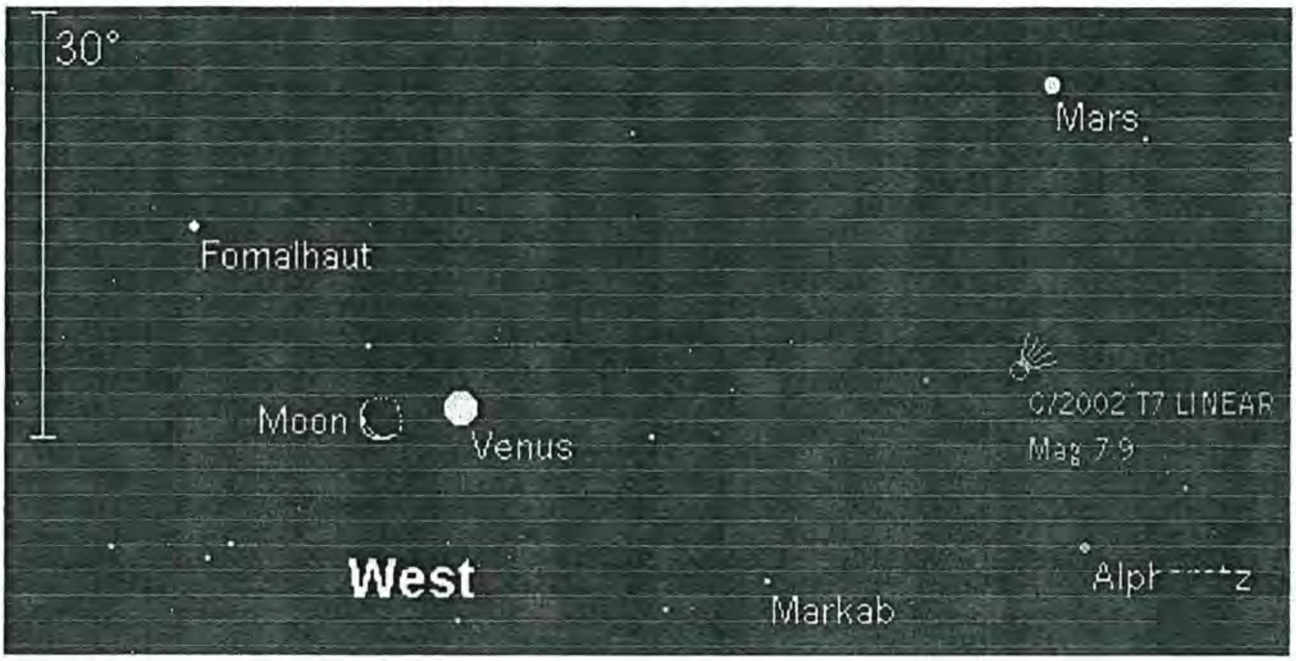
Just to the left of the False Cross is a good open cluster. Canopus (alpha Carina) is a bright yellowish star sitting 11 handspans above the south-eastern horizon (and about 4 handspans up from the False Cross.

Directly above the southern horizon by 11 handspans is the extended nebulosity of the Large Magellanic cloud, the largest of the dwarf satellite galaxies. Binoculars will reveal a rather attractive nebula near it, the Tarantula nebula.

To the left of this by 4 handspans is the Small Magellanic cloud, the second largest of the dwarf satellite galaxies to the Milky Way. In this nebulosity is what looks to be a fuzzy star, this is 47 Tucana, a spectacular globular cluster that is very nice through binoculars.

To the right of the Small Magellanic Cloud by about 4 handspans is the dim constellation of Tucana, the Toucan, the parent constellation of 47 Tucana.

http://home.mira.net/%7Ereynella/skywatch/ssky.htm



POVG MEETING - MINUTES

Minutes of Meeting. Nov 24th 03

Meeting Commenced at 7.05

Present. R.Tonello.R.Boelin.D Emrich.J.Milner. L.Martin. E.Walker T.Smith. J.Alcroft. G.Coletti. J.Morris. D.Alderson.T.Dunn. S.Schediwy. T.Beardsmore. L.Robinson. P.Birch. V.Levis. M.Freeman. F.Bilki. B.Harris.

Apologics. B.Hollcbon. R.Loncy. M.Zengerer. T.Beston. E.Cowlishaw L.Bell. J.Biggs. V.Smith.

Minutes of the previous meeting. Agreed as a true and correct record On the motion of J.Alcroft and F.Bilki.

Treasurer's Report. No change from the previous meeting. Bank balanceremains at $210.33

General Business.

1. G.Lowe reported that J.Biggs was in hospital for a minor operation, the members wished him a speedy recovery.

2. B.Harris gave a brief report on his participation with the Solar Challenge vehicle.

3. G.Lowe reminded members of the donation of the ìFlamstead Star Atlas ì on display in the Display Room and reported with regret that Mr.M.Moffatt, one of the Donars had recently passed away.

4. He also informed members that there was now a new Galvanised Metal Fuse box, that contained the switches to control the lights In the Car Park and Toilets.

5. P.Birch stated applications for Toms position were now closed and a decision would be finalised by Christmas.

6. T.Dunn stated that for personal reasons he wished to temporarily Stand down from the position as Chairman until after Christmas.

There being no further General Business the meeting closed at 7.20

PHASES OF THE MOON FOR 2004 (WA TIME)

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	Jan 15 12:46
Jan 22 05:05	Jan 29 14:03	Feb 6 16:47	Feb 13 21:40
Feb 20 17:18	Feb 28 11:24	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	Apr 5 19:03	Apr 12 11:46
Apr 19 21:21	Apr 28 01:32	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hpc5mn03.htm

DON'T MISS
the SUMMER LECTURE

PROF RAY NORRIS of ATNF, Sydney,

Date: Sun 15 Feb, 8pm. Perth Observatory.

Tickets to the public are just $5.00.
Please invite or promote other to attend.

2004 VOLUNTEER TRAINING/MEETING NIGHTS

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

2004
Jan 19
Feb 23
Mar 15
Apr 19
May 17
Jun 14
Jul 12
Aug 9

PERTH OBSERVATORY VOLUNTEERS GROUP INC.

OBSERVATORY'S VOLUNTEER ACTIVE MEMBER LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake
Trevor Dunn
David Emich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
James Healy
Bert Hollebon
Karen Koltze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Kylie Ralph
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Robert Taylor
Patricia Turner
Elaine Walker
Sandra Walker
Matthew Zengerer

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

(To be advised)	Chairperson
Karen Koltze	Vice Chair
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator

(contact bevan on ngc2070@bigpond.com)

Jeff Alcroft	Newsletter Editor

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

POVG
Perth Observatory Volunteers Group

Biggs, James

From: IAUC mailing list [quai@cfa.harvard.edu]
Sent: 06 February 2004 05:49
To: astro@pd.uwa.edu.au
Subject: IAUC 8282: 2004S; 2001em; C/2003 H1

Circular No. 8282
Central Bureau for Astronomical Telegrams
INTERNATIONAL ASTRONOMICAL UNION
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CBAT@CFA.HARVARD.EDU (science)
URL http://cfa-www.harvard.edu/iau/cbat.html ISSN 0081-0304
Phone 617-495-7440/7244/7444 (for emergency use only)

SUPERNOVA 2004S IN MCG -05-16-21

R. Martin, Perth Observatory, reports the discovery of an apparent supernova (mag 16) on red CCD images taken on Feb. 3.542 and 4.560 UT with the 0.61-m Perth/Lowell Automated Telescope in the course of the Perth Automated Supernovae Search. SN 2004S was not visible on an image taken on 2003 Dec. 30.583 (limiting mag 19). J. Biggs reports the following position for SN 2004S from an unfiltered images taken around 2004 Feb. 5.65, when the object appeared at R about 13.6 +/- 0.3: R.A. = 6h45m43s.50 +/- 0".1, Decl. = -31o13'52".5 +/- 0".1 (equinox 2000.0), which is 47".2 west and 2".5 south of the nucleus of MCG -05-16-21.

SUPERNOVA 2001em IN UGC 11794

C. J. Stockdale, Marquette University; S. D. Van Dyk, Infrared Processing and Analysis Center, California Institute of Technology; R. A. Sramek, National Radio Astronomy Observatory (NRAO); K. W. Weiler, Naval Research Laboratory; N. Panagia, European Space Agency and Space Telescope Science Institute; M. P. Rupen, NRAO; and B. Paczynski, Princeton University, report the detection of radio emission near the position of the type-Ib/c supernova 2001em (IAUC 7722, 7737) with the Very Large Array (VLA): "Radio-flux densities on 2003 Oct. 17.18 UT of 1.151 +/- 0.051 mJy at 8.435 GHz (wavelength 3.6 cm), and on 2004 Jan. 30.90 of 1.815 +/- 0.099 mJy at 4.860 GHz (wavelength 6.2 cm), 1.480 +/- 0.052 mJy at 8.460 GHz, and 1.200 +/- 0.162 at 14.94 GHz (2.0 cm), were observed at R.A. = 21h42m23s.61, Decl. = +12o29'50".3 (equinox 2000.0; +/- 0".2 in each coordinate). This is in near coincidence (< 1") with the reported optical position of SN 2001em (position end figures 23s.66, 50".9; IAUC 7722). The source appears variable at 3.6 cm and is mildly non-thermal (alpha = -0.37; S is proportional to nu**alpha) between 4.9 and 14.9 GHz. SN 2001em appears to be the most luminous (currently about 2 x 10**28 erg s**-1 Hz**-1 at 6 cm for a distance of 90 Mpc) type-Ib/c supernova ever observed at such a late epoch, about fifty times more radio luminous than SN 1998bw at a comparable age. We are continuing to monitor this source with the VLA."

COMET C/2003 H1 (LINEAR)

Visual total-magnitude estimates: Jan. 20.23 UT, 13.3 (J. J. Gonzalez, Asturias, Spain, 0.20-m reflector); 25.86, 13.0 (K. Yoshimoto, Yamaguchi, Japan, 0.25-m reflector); Feb. 1.23, 12.7 (Gonzalez).

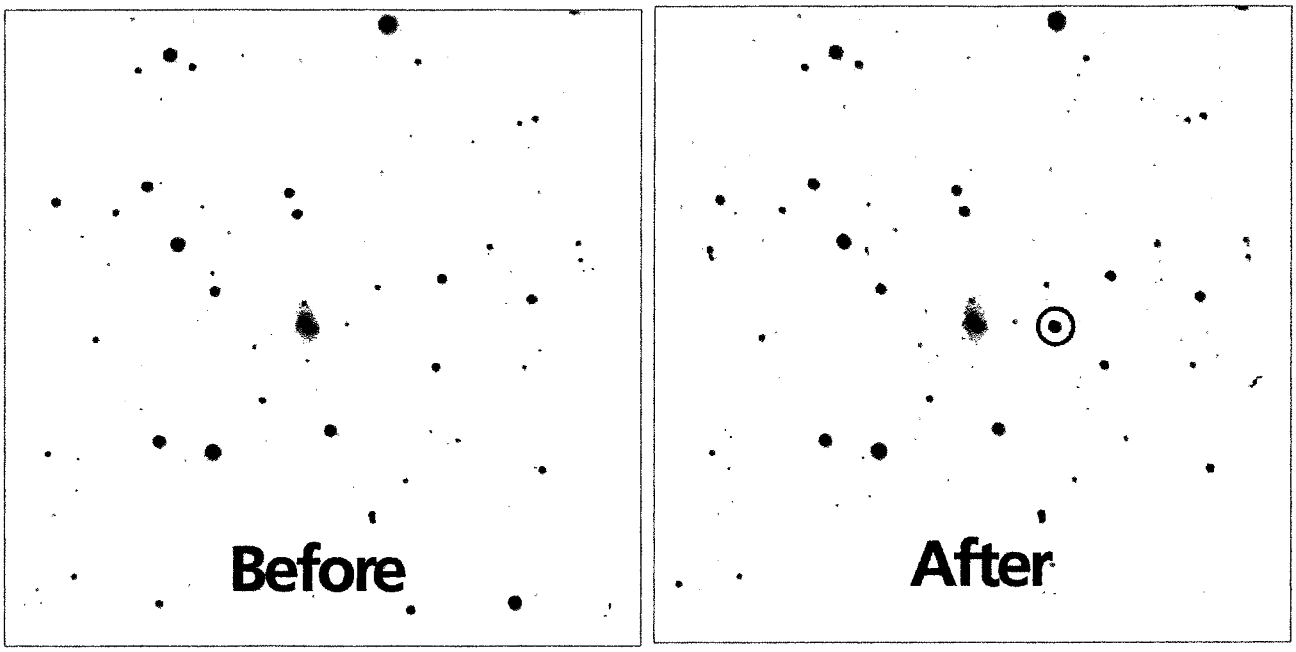
2004 February 5 (8282) Daniel W. E. Green

FEBRUARY 2004

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

Perth Observatory discovers Supernova!



Ralph's images of the new SUPERNOVA 2004S IN MCG -05-16-21found by Ralph. Perth Observatory.

Hi Vollies,
Just thought you might be interested in the following - Ralph has done it again. This is discovery number 20. Cheers Peter Birch.

SUPERNOVA 2004S
IN MCG -05-16-21

R. Martin, Perth Observatory, reports the discovery of an apparent supernova (mag 16) on red CCD images taken on Feb. 3.542 and 4.560 UT with the 0.61-m Perth/Lowell Automated Telescope in the course of the Perth Automated Supernovae Search. SN 2004S was not visible on an image taken on 2003 Dec. 30.583 (limiting mag 19).

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IN THIS ISSUE:

- ✦ POVG MEETING MINUTES ✦ PHASES OF THE MOON
- ✦ VOLLIE TRAINING/MEETING NIGHTS - DATES AND TIMES
- ✦ ASTRONOMY NEWS & EVENTS FOR FEBRUARY

PLANETOID FOUND IN KUIPER BELT, MAYBE THE BIGGEST YET

Planetary scientists have discovered a new planetoid in the outer fringes of the solar system. The planetoid, currently known only as 2004 DW, could be even larger than Quaoar — the current record holder in the area known as the Kuiper Belt — and is some 4.4 billion miles from Earth. http://spaceflightnow.com/news/n0402/20kuiper/

SHUTTLE TANK MODIFICATIONS MORE COMPLEX THAN EXPECTED

After months of testing and computer analyses, engineers believe they understand the phenomena that causes foam insulation to separate from the space shuttle's external fuel tank during launch. But preventing such foam shedding has turned out to be more difficult than originally thought, a top NASA manager said today, and tank modifications remain a major challenge. http://spaceflightnow.com/shuttle/sts114/040220tank/

FADING SUPERNOVA PRODUCES SPECTACULAR NEW LIGHT SHOW

Seventeen years ago, astronomers spotted the brightest stellar explosion ever seen since the one observed by Johannes Kepler 400 years ago. Called SN 1987A, the titanic supernova explosion blazed with the power of 100,000,000 suns for several months following its discovery. Although the supernova itself is now a million times fainter than 17 years ago, a new light show in the space surrounding it is just beginning. http://spaceflightnow.com/news/n0402/19supernova/

OPPORTUNITY PROBES TRENCH; SPIRIT DIGS ONE, TOO

By inspecting the sides and floor of a hole it dug on Mars, NASA's Opportunity rover is finding some things it did not see beforehand, including round pebbles that are shiny and soil so fine-grained that the rover's microscope can't make out individual particles. Meanwhile, twin rover Spirit has dug a trench on its way to Bonneville Crater.

GIANT BLACK HOLE DESTROYS UNLUCKY STAR

A super-massive black hole has ripped apart a star and consumed a portion of it, according to data from ESA's XMM-Newton and NASA's Chandra X-ray observatories. These results are the best evidence yet that such a phenomenon, long predicted by theory, does actually happen. http://spaceflightnow.com/news/n0402/18starblackhole/

PRIME MISSION HALF OVER, SPIRIT LOOKS FOR BONUS TIME

The first Mars Exploration Rover, beset for a time by computer troubles but now trekking on a geology adventure to an impact crater, has reached the midway mark of its primary mission. http://spaceflightnow.com/mars/mera/040218spiritsol45.html

KOSMOS 2405 MILITARY PAYLOAD LAUNCHED BY RUSSIA

With President Vladimir Putin looking on, Russia's largest military exercise in over two decades took to the high frontier Wednesday with the launch of a clandestine payload from the nation's northern space base near the Arctic Circle. http://spaceflightnow.com/news/n0402/18molniya/

OPPORTUNITY DIGS MARS

The Mars Exploration Rover Opportunity is putting its mark on the Red Planet, digging a small hole so its suite of science instruments can probe soil enriched with hematite, a mineral that typically forms in the presence of water. http://spaceflightnow.com/mars/mera/040217trench.html

ROAD TRIP TO BONNEVILLE CRATER CONTINUES FOR SPIRIT

Proving to be a real Mars hotrod, the Spirit rover has become the most traveled vehicle on the Red Planet, surpassing the distance accumulated by the Pathfinder rover nearly seven years ago. http://spaceflightnow.com/mars/mera/040217spirit.html

ROSETTA COMET PROBE IS A SPACE SOPHISTICATE

The European Space Agency's Rosetta mission to rendezvous with Comet 67P/Churyumov-Gerasimenk is certainly not a short trip. Rosetta will need ten years just to reach the comet. This places extreme demands on its hardware; when the probe meets up with the comet, all instruments must be fully operational, especially since it will have been in "hibernation" for two-and-a-half years of its journey. http://spaceflightnow.com/ariane/v158/040216sophisticate.html

FARTHEST KNOWN GALAXY IN THE UNIVERSE DISCOVERED

An international team of astronomers may have set a new record in discovering what is the most distant known galaxy in the Universe. Located an estimated 13 billion light-years away, the object is being viewed at a time only 750 million years after the big bang, when the Universe was barely 5 percent of its current age. http://spaceflightnow.com/news/n0402/15lens/

NEW SATELLITE TO PROVIDE U.S. WITH MISSILE WARNINGS

The U.S. military's newest orbiting sentry was successfully deployed Saturday, joining a space surveillance system that maintains a constant vigil 22,300 miles above Earth to detect enemy missile launches and nuclear weapon detonations. The Titan 4B rocket launched the Defense Support Program-22 satellite from Cape Canaveral, Florida. http://spaceflightnow.com/titan/b39/index.html

TWIN MARS ROVERS CONTINUE THEIR SCIENTIFIC ACTIVITIES

The Mars Exploration Rover Spirit is examining a collection of rocks, including a flaky one nicknamed Mimi, on its lengthy drive to a crater.
Meanwhile, Opportunity is preparing to dig a hole to study the soil at itslanding site. http://spaceflightnow.com/mars/mera/status.html

FAR AWAY QUASARS PROBE END OF COSMIC DARK AGES

The most distant known quasars show that some supermassive black holes formed when the universe was merely 6 percent of its current age, or about 700 million years after the big bang. http://spaceflightnow.com/news/n0402/14darkages/

ULYSSES MISSION EXTENDED

The European Space Agency's Science Programme Committee has unanimously approved a proposal to continue operating the highly successful Ulysses spacecraft until March 2008. This latest extension, the third in the history of the joint ESA-NASA mission, will enable Ulysses to add an important chapter to its survey of the high-latitude heliosphere. http://spaceflightnow.com/news/n0402/14ulysses/

SPITZER SPACE TELESCOPE SENDS COSMIC VALENTINE ROSE

A cluster of newborn stars herald their birth in this interstellar Valentine's Day commemorative picture obtained with NASA's Spitzer Space Telescope. These bright young stars are found in a rosebud-shaped (and rose-colored) nebulosity known as NGC 7129. The star cluster and its associated nebula are located at a distance of 3300 light-years in the constellation Cepheus. http://spaceflightnow.com/news/n0402/12spitzerrose/

BEAGLE FAILURE INVESTIGATION FORMALLY BEGINS

Launched on a shoestring budget, its size tightly confined, the British Beagle 2 lander headed to Mars for a highly-ambitious mission to look for evidence of life. A Christmas Day touchdown on the Red Planet was planned, but the craft never phoned home and subsequent weeks of searching turned up only silence. http://spaceflightnow.com/mars/marsexpress/040211board.html

GRAVITATIONAL LENS REVEALS HEART OF A DISTANT GALAXY

Many examples are known where a galaxy acts as a gravitational lens, producing multiple images on the sky of a more distant object like a bright quasar hidden behind it. But there has been a persistent mystery for over 20 years: Einstein's general theory of relativity predicts there should be an odd number of images, yet almost all observed lenses have only 2 or 4 known images. Now, astronomers have identified a third, central image of a lensed quasar. http://spaceflightnow.com/news/n0402/11lens/

SUPERNOVA BLAST BONANZA IN NEAR-BY GALAXY

A nearby dwarf galaxy is a hotbed of vigorous star birth activity which blows huge bubbles that riddle the main body of the galaxy. The galaxy's "star factories" are also manufacturing brilliant blue star clusters. This galaxy had a sudden and relatively recent onset of star birth about 25 million years ago, which subsided about the time the very earliest human ancestors appeared on Earth. http://spaceflightnow.com/news/n0402/03hubble/

2005 BUDGET TO FUEL NASA'S NEW EXPLORATION PLAN

NASA Administrator Sean O'Keefe presented the Bush Administration's fiscal year 2005 budget proposal on Tuesday. The spending plan would implement the new U.S. space exploration policy. http://spaceflightnow.com/news/n0402/03nasabudget/

ROVER'S ARM REACHES FOR CLUES ABOUT MARS' HISTORY

Lending a hand to unlock the geologic riddles of Mars, the rover Opportunity has extended its instrument-laden arm to begin probing soil on the floor of a small crater where the craft landed. http://spaceflightnow.com/mars/mera/040202arm.html

MARTIAN HILLS DEDICATED TO FALLEN COLUMBIA CREW

The Martian hills, located east of the Spirit Mars Exploration Rover's landing site, will be dedicated to the space shuttle Columbia STS-107 crew, NASA Administrator Sean O'Keefe announced Monday. http://spaceflightnow.com/mars/mera/040202columbiahills.html

OXYGEN, CARBON DISCOVERED IN EXOPLANET ATMOSPHERE

The well-known extrasolar planet HD 209458b, provisionally nicknamed Osiris, has surprised astronomers again. Oxygen and carbon have been found in its atmosphere, evaporating at such an immense rate that the existence of a new class of extrasolar planets - 'the chthonian planets' or 'dead' cores of completely evaporated gas giants - has been proposed. http://spaceflightnow.com/news/n0402/02planet/

BIG BANG ECHOES CORRUPTED?

In recent years, astronomers have obtained detailed measurements of the cosmic microwave background radiation - the 'echo' from the birth of the Universe during the Big Bang. But now a group of UK astronomers has found evidence that the primordial microwave echoes may have been modified or 'corrupted' on their 13 billion year journey to the Earth. http://spaceflightnow.com/news/n0402/02bigbang/

COMET BLAMED FOR 6TH CENTURY 'NUCLEAR WINTER'

Scientists at Cardiff University, UK, believe they have discovered the cause of crop failures and summer frosts some 1,500 years ago -a comet colliding with Earth.

The team has been studying evidence from tree rings, which suggests that the Earth underwent a series of very cold summers around 536-540 AD, indicating an effect rather like a nuclear winter.

The scientists in the School of Physics and Astronomy believe this was caused by a comet hitting the earth and exploding in the upper atmosphere. The debris from this giant explosion was such that it enveloped the earth in soot and ash, blocking out the sunlight and causing the very cold weather. This effect is known as a plume and is similar to that which was seen when comet Shoemaker-Levy-9 hit Jupiter in 1995.

Historical references from this period - known as the Dark Ages - are sparse, but what records there are, tell of crop failures and summer frosts. The surprising result of the new work is just how small a comet is needed to cause such dramatic effects. The scientists calculate that a comet not much more than half a kilometre across could cause a global nuclear winter effect. This is significantly smaller than was previously thought. "One of the exciting aspects of this work is that we have re-classified the size of comet that represents a global threat. This work shows that even a comet of only half a kilometre in size could have global consequences. Previously nothing less than a kilometre across was counted as a global threat. If such an event happened again today, then once again a large fraction of the earth's population could face starvation."

The comet impact caused crop failures and wide-spread starvation among the sixth century population. The timing coincides with the Justinian Plague, widely believed to be the first appearance of the Black Death in Europe. It is possible that the plague was so rampant and took hold so quickly because the population was already weakened by starvation. CARDIFF UNIVERSITY NEWS RELEASE Posted: February 7, 2004

http://spaceflightnow.com/news/n0402/07darkages/

NEW EVIDENCE FOR MAJOR PUNCTUATION OF GLOBAL CLIMATE AT THE PLEISTOCENE/ HOLOCENE BOUNDARY

"...A growing accumulation of geological evidence is making it ever clearer that in the past the climate has undergone drastic changes in temperature and rainfall patterns in the space of a human lifetime, in a decade or in even less time."

"....In uncovering one of the latest pieces of evidence of abrupt climate change, American scientists led by Dr. Jeffrey P. Severinghaus of the University of Rhode Island examined climatic clues taken from corings of ancient ice in Greenland.

"The Severinghaus team determined that when the world began its final ascent out of the last ice age more than 11,000 years ago, temperatures in Greenland initially spiked upward by about 9 to 18 degrees F. — at least a third, and perhaps more, of the total recovery to today's warmth — in, at most, mere decades and probably less than a single decade. They also found that the impact of the sudden warming had been felt at least throughout the Northern Hemisphere.

"That amount of heating, coming so quickly, is astounding," said Dr. Richard Alley of Pennsylvania State University, a member of the study team. Another recent study, by Dr. Peter deMenocal, a paleoclimatologist at Lamont-Doherty, examined clues in Atlantic Ocean sediments off subtropical

North Africa. He discovered that every 1,500 years or so since the end of the ice age, ocean temperatures there have fluctuated wildly and abruptly.

"In a cold phase, they fell by 5 to 15 degrees, and seasonal rains on the continent were severely curtailed — all within no more than 50 to 100 years, and possibly less (the sediment analysis is not fine enough to tell). Then, in another 1,500 years, the picture reversed just as abruptly, causing flooding rains and creating widespread lakes in what is now the Sahara.

"The transitions are sharp," Dr. deMenocal said. "Climate changes we thought should take thousands of years to happen occur within a generation or two," at most. The changes may have wreaked havoc on nascent civilizations in Africa and the Middle East. "It was certainly something that would have rocked somebody's world," Dr. deMenocal said.. From: Clark Whelton whel@worldnet.att.net

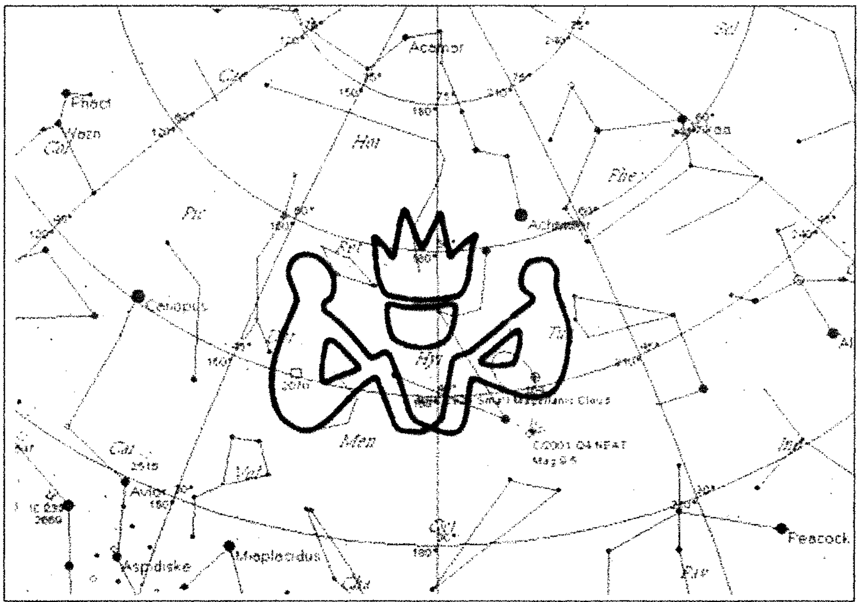
The New York Times Science Section, January 27, 1998

If Climate Changes, It May Change Quickly.

William K. Stevens CAMBRIDGE-CONFERENCE DIGEST, 29 January 1998.

http://abob.libs.uga.edu/bobk/ccc/cc012998.html

ABORIGINAL CONSTELLATION OF THE MONTH
SUMMERTIME: KOURT-CHIN – THE OLD PEOPLE



Near the south celestial pole are two objects that look like clouds floating in the night sky, roughly forming an equilateral triangle with the pole. To some Aboriginal groups they represent Kourt Chin, the old people of the tribe, who are watching over their families. The smaller cloud is the woman, and the larger is the man. The nearby bright star, known to some tribes as Palana, represents the food the old people have cooked on their fire. Respect for and remembrance of older community members is an essential belief of all Aboriginal groups, and it features prominently in many of their customs.

The clouds are of course the Clouds of Magellan, or Magellanic Clouds, and Palana is the star we now know as Achernar. The Magellanic Clouds were first sighted by sailors rounding the Cape of Good Hope and were originally known as the Cape Clouds. Some years later they were named after Spanish navigator Ferdinand Magellan. The Large Magellanic Cloud (LMC) lies within the constellation Doradus and occupies an area of nearly 10 degrees square, 400 times that of the full moon. It contains the popular telescope object 30 Doradus, the Tarantula Nebula (NGC 2070), and was also home to supernova SN 1987A, which was observed in February 1987. The Small Magellanic Cloud (SMC) falls within the constellation Toucana and covers an area of around 5 x 3 degrees. Nearby is the excellent globular cluster 47 Tucanae (NGC 104), which is one of the two best globular clusters in the night sky.

Contributor: Frank Bilki

OCCULTATION EXPLAINED

An occultation occurs when the Moon covers and uncovers a more distant object such as a planet, star or an asteroid.

Why does an occultation occur? Within any one night most objects that can be seen in the night sky do not change their relative position to each other. The stars and the planets will rise and set, but the pattern they form will remain steady throughout the night. The Moon is relatively close to us - only 400,000 kilometers (240,000 miles) from Earth and it revolves around the Earth about once a month. Although the Moon also rises and set almost the same as the stars, it does change its position relative to the stars and the planets.

As the Moon rotates around the Earth, moving across the background of the stars and planets, it will occasionally cover up a planet and then uncover the same planet. This "immersion" and "remersion" of the planet (or a star) is an occultation.

When and where can I see an occultation? In order to see an occultation, but the planet or star, the Moon's edge and you must be in a straight line. Generally there is a path on the Earth from which a particular occultation can be seen. Software is available to do these calculations. For an occultation to be determined within a few seconds, it is necessary to know your location to a high degree of accuracy. SkyWatch provides warning of occultations of Planets to its subscribers. Once the time of an occultation is known, it's easy enough to see it because it will take place at the Moon's edge.

What objects can be occulted by the Moon?

Any object that lies in the Moon's path and beyond the Moon may be occulted. Fortunately, most of the interesting objects within the Solar System are along the ecliptic - a line indicating the path of the Sun, Moon and the planets. The Moon will not cover up and cause an occultation of a planet or star ever time it revolves around the Earth, because sometimes the Moon will the object and be above or below the object's path.

What so important about occultations?

The timing of occultation provides important information about the structure of the Solar System and the location of stars. Amateur astronomers have provided a valuable service to the professionals by making accurate timing of these events. Others just like to see a star disappear or reappear on schedule. If the Moon is not full, the star will simply disappear at the correct time. At worse occultation can be used to impress your friends. At best it will increase your understanding on how the universe actually works.

http://www.sky-watch.com/occult.html
http://www.astronomynow.com/night_sky.html#calendar

SKY EVENTS FOR FEBRUARY 2004

METEOR SHOWERS

The Delta Leonids (DLE) peak on February 25 with a ZHR of two. Current rates would be less than one per hour. The radiant is located at 10:40 (160) +19. This area of the sky is located in central Leo, four degrees east of the second magnitude star Algeiba (Gamma Leonis). With an entry velocity of 23 kilometers per second, these meteors will appear to move slowly.

http://www.amsmeteors.org/lunsford/

Observing

The activity of this stream persists from February 5 to March 19. The shower reaches maximum on February 22, from an average radiant of RA=156 deg, DECL=+18 deg. The ZHR is 3, while the average magnitude of the meteors is near 2.86. A possible telescopic southern branch may have a duration extending from January 13 to February 24, with a maximum on February 3 and an average radiant of RA=135 deg, DECL=+8 deg.

http://spaceflightnow.com/mars/mera/status.html

PLANETS THIS MONTH:

Mercury is visible in the morning sky in February. On the 1st, it is two handspans above the south eastern horizon, half an hour before sunrise. By the 15th, it is a handspan above the south eastern horizon, half an hour before sunrise. On the morning of the 19th the crescent Moon will be a hand span above Mercury. By the end of the Month, Mercury is no longer visible.

Venus is prominent in the evening sky. On the 1st Venus is three handspans above the western horizon, half an hour after sunset. On the evenings of the 23rd and 24th the crescent Moon will be under a handspan to the left, and right of Venus respectively. By the end of the month Venus will remain three handspans above the horizon half an hour after sunset.

Mars is fading rapidly, and almost featureless in most small telescopes, despite being distinctly gibbous. Mars is visible in the western evening sky, and is the brightest object in the western sky apart from Venus. On the evening of the 26th the Moon will be two fingerwidths from Mars.

Jupiter rises around 10.00pm at the begining of this month, and by the end of the month it rises around 8.00pm AEDST. On the 1st Jupiter is the brightest object three handspans above the north-eastern horizon at around midnight. On the morning of the 8th the waning Moon will be three fingerwidths below Jupiter. On the 28th Jupiter is the brightest object three handspans above the north-eastern horizon at around 10.00 pm AEDST. Jupiters moons are a fine sight in binoculars.

Saturn is visible high in the evening sky. On the 1st Saturn is the brightest object five handspans above the northern horizon around 10.00 pm AEDST. It is also about two handspans above and to the left of the pair of bright stars Castor and Pollux. On the 2nd and the 3rd the waxing Moon will be just over a handspan from Saturn By the end of the month Saturn is still high in the northern sky by 10.00 pm AEDST. Saturns rings are the widest they have been for some time. This is an excellent time to look at Saturn in even a small telescope.

http://home.mira.net/%7Ereynella/skywatch/ssky.htm#Meteor

UPCOMING EVENTS

May 2004 is a very busy month, not only is the Moon, Venus, Mars, Jupiter and Saturn together in the night sky, but:

There will be a total eclipse of the Moon on 5 May, 2004.

Comet 2001 Q4 NEAT should become a naked eye comet (but not spectacular) in the Southern Hemisphere in May 2004.

Comet 2002 T7 should also become a naked eye comet, possibly spectacular, in the Southern Hemisphere at around the same time as Comet 2001 Q4 NEAT.

Venus will transit the Sun on June 8 2004.

There will be a Blue Moon on August 30th, 2004.

The Moon will pass in front of Venus on November 10, 2004.

Mars and the Sun from Opportunity. Image source NASA.

POVG MEETING - MINUTES

Perth Observatory Volunteer Group Incorporated.
Minutes of Meeting.
Jan. 19th 2004.
PRESENT.

R.Boelin. D.Emrich. B.Hollebon. J.Morris. J.Biggs. T.Dunn. T.Beston. J. Alcroft. T.Beardsmore. G.Lowe. V.Semmler. K.Kotze. M.Freeman. J.Milner. B.Harris. G.Coletti. E.Cowlishaw. L.Martin. L.Bell L.Robinson.

APOLOGIES.

V.Smith. F.Bilki. J.Bell. P.Birch.

Minutes of the Previous Meeting.
Agreed that they are a true and correct record on the motion of J.Alcroft. Seconded by R.Boelin.

Treasurer's Report.

B.Harris stated that there had been no change in the financial situation from last Meetings report.

GENERAL BUSINESS.

J.Morris reported that the Bench seats purchased by the Group were down to the bare wood and needed re-varnishing. J.Biggs stated that to comply with the recommendations of the Health and Safety Officer from C.A.L.M, they would have to be painted white.

G.Lowe reported that there had been two minor accidents at the telescopes , A lady had fallen whilst exiting the C.14 Dome, and another lady had slipped and fallen from the ladder in the V.O.F.

M.Freeman complimented the Observatory on the provision of the new Ladder in the V.O.F. it should prove much safer.

J.Morris stated that he had been in contact with the A.C.R.O.D, and Independent Living Group. and that an item recommending a visit to the Observatory had been sent out in their Newsletters.
G.Lowe outlined some difficulties in the use of the Pantagraph with certain disabled people.

T Dunn Chairman repeated his intention to stand down from the position of Chairman. Due to personal reasons and asked for nominations for the position .

J.Biggs on behalf of all the Observatory Staff thanked Trevor for his efforts in obtaining the Grants from the Lotteries Commission, for his drive in turning the Volunteers into an Incorporated Body, and for his assistance in the service to the public.

Following much discussion M.Freeman agreed to take on the position of Chairman , it was moved J.Morris , seconded by K.Kotze and agreed by all that M.Freemans offer be accepted.

There being no further General Business the meeting closed at 8.45pm

PHASES OF THE MOON FOR 2004 (WA TIME)

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	**Jan 15 12:46**
Jan 22 05:05	**Jan 29 14:03**	**Feb 6 16:47**	**Feb 13 21:40**
Feb 20 17:18	**Feb 28 11:24**	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	Apr 5 19:03	Apr 12 11:46
Apr 19 21:21	Apr 28 01:32	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hpc5mn03.htm

Congratulations to Mike Freeman, our new Vollie Chairperson!

2004 VOLUNTEER TRAINING & MEETING NIGHTS

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

- Mar 15
- Apr 19
- May 17
- Jun 14
- Jul 12
- Aug 9

PERTH OBSERVATORY VOLUNTEERS GROUP INC.

OBSERVATORY'S VOLUNTEER ACTIVE MEMBER LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake
Trevor Dunn
David Emich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
James Healy
Bert Hollebon
Karen Koltze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Kylie Ralph
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Robert Taylor
Patricia Turner
Elaine Walker
Sandra Walker
Matthew Zengerer

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

Mike Freeman	Chairperson
Karen Koltze	Vice Chair
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator

(contact bevan on ngc2070@bigpond.com)

Jeff Alcroft	Newsletter Editor

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

POVG
Perth Observatory Volunteers Group

THE ASTROPHYSICAL JOURNAL, 594:961–970, 2003 September 10

CONSTRAINING THE EVOLUTION OF ZZ CETI

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Received 2003 April 15; accepted 2003 May 19

ABSTRACT

We report our analysis of the stability of pulsation periods in the DAV star (pulsating hydrogen atmosphere white dwarf) ZZ Ceti, also called R548. On the basis of observations that span 31 years, we conclude that the period 213.13 s observed in ZZ Ceti drifts at a rate $dP/dt \leq (5.5 \pm 1.9) \times 10^{-15}$ s s^{-1}, after correcting for proper motion. Our results are consistent with previous $\dot{P}$ values for this mode and an improvement over them because of the larger time base. The characteristic stability timescale implied for the pulsation period is $|P/\dot{P}| \geq 1.2$ Gyr, comparable to the theoretical cooling timescale for the star. Our current stability limit for

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the period 213.13 s is only slightly less than the present measurement for another DAV, G117-B15A, for the period 215.2 s, establishing this mode in ZZ Ceti as the second most stable optical clock known, comparable to atomic clocks and more stable than most pulsars. Constraining the cooling rate of ZZ Ceti aids theoretical evolutionary models and white dwarf cosmochronology. The drift rate of this clock is small enough that we can set interesting limits on reflex motion due to planetary companions.

Subject headings: stars: evolution — stars: individual (ZZ Ceti, R548) — stars: oscillations — stars: variables: other — white dwarfs

1. INTRODUCTION

Global pulsations of stars can be used to probe their interiors, similar to the method of using earthquakes to explore the Earth's interior. This technique, called asteroseismology, is a unique method to study stellar interiors.

The observed properties of the currently known classes of pulsating white dwarfs place them in three different temperature ranges: the high-temperature instability strip consists of the PNNV (planetary nebula nuclei variable) and the DOV (hot degenerate variable; GW Vir) stars at an effective temperature of 80,000–170,000 K and $\log g \approx 6$; the DBV (helium atmosphere variable) instability strip occurs around 25,000 K, $\log g \approx 8$; while the DAV (hydrogen atmosphere variable) instability strip is found between 11,000 and 12,500 K, $\log g \approx 8$ (see the review paper Winget 1998 and the references therein). The DAV white dwarf stars are also known as the ZZ Ceti stars after ZZ Ceti (R548), the prototype of the class. Their pulsation periods are typically 100–1200 s, consistent with nonradial g-mode pulsations. Pulsating DA white dwarfs (DAVs) are not unusual or special in any way; all known DAs pulsate when their temperatures reach the DAV instability strip (Robinson 1979; Fontaine et al. 1985); i.e., pulsation is an evolutionary phase.

There are two competing internal evolutionary processes that govern the change in pulsation period with time ($\dot{P}$) for a single mode in the theoretical models of the ZZ Ceti stars. Cooling of the star increases the period as a result of the increasing degeneracy, and residual gravitational contraction decreases the period (Winget, Hansen, & Van Horn 1983). For high effective temperatures, as in the DOV/PNNV instability strip, contraction is still significant. Kepler et al. (2000) conclude that the evolutionary $\dot{P}$ is dictated by the rate of cooling for the DAV stars, and contraction is not significant in the temperature range of the DAV instability strip.

The cooler DAV stars exhibit many pulsation modes, the amplitudes of which are observed to change significantly on timescales that are orders of magnitude shorter than the evolutionary cooling (Kleinman et al. 1998). Near the high-temperature (blue) edge of the DA instability strip, we observe the pulsation periods and amplitudes to be highly stable. This implies that a hot DAV star should show a $\dot{P}$ reflective of its cooling rate. G117-B15A is a hot DAV star with a constraining limit $\dot{P} \leq (2.3 \pm 1.4) \times 10^{-15}$ s s^{-1} for the 215.1973907 s period (Kepler et al. 2000). We define a stability timescale $\tau_s \equiv \mid P/\dot{P} \mid$; it is the time taken by a clock to lose or gain a cycle. G117-B15A is the most stable optical clock known, with $\tau_s \geq 3.0$ Gyr.

When we measure the cooling rate of a DAV, it applies to all white dwarfs of that temperature, mass, and chemical composition, as pulsation is only a phase in the life of the star. By measuring the cooling rate of another hot DAV such as ZZ Ceti, we are providing a second independent measurement of the cooling rate of a 12,000 K white dwarf. A second measurement is important to apply the results to DA white dwarfs as a class; the DAs constitute 80% of the white dwarf population.

Monitoring the stable hot DAV stars has at least two interesting applications (see § 8). White dwarf evolution is dominated by cooling, leading to a simple relation between effective temperature and age of the white dwarf, described approximately by Mestel cooling theory (Mestel 1952; Van Horn 1971). Measuring the cooling rates of white dwarfs proves helpful in calibrating the white dwarf cooling curve. This reduces some of the theoretical uncertainty in white dwarf cosmochronometry (e.g., Winget et al. 1987; Hansen et al. 2002). Second, stable clocks with an orbital planet will show a detectable reflex motion around the center of mass of the system, providing a means to detect the planet (Kepler et al. 1990, 1991; Mukadam, Winget, & Kepler 2001). Theoretical work indicates outer terrestrial planets and gas giants will survive (e.g., Vassiliadis & Wood 1993) and be stable on timescales longer than the white dwarf cooling time (Duncan & Lissauer 1998). The success of a planet search with this technique around stable pulsators relies on finding and monitoring a statistically significant number of hot DAV stars.

Using standard evolutionary theory, Bradley, Winget, & Wood (1992) estimated the cooling timescale, i.e., $T/\dot{T}$, for a hot DAV at about 12,000 K to be a few billion years. We thus expect the pulsational stability timescale ($P/\dot{P}$) to be a few billion years, which implies that we need decades of data to get a detectable change in period. G117-B15A, ZZ Ceti (R548), L19-2, and G226-29 are four hot DAV stars with suitable time spans of archival data, and we intend to monitor all of them. In this paper, we present our work on ZZ Ceti.

2. OBSERVATIONS

We obtained time series photometry data on ZZ Ceti from 1970 to 1993, most of which were acquired with phototubes. We also have data from the 3.6 m Canada-France-Hawaii Telescope (CFHT), acquired in 1991. Additionally, ZZ Ceti was included as a secondary target star in the Whole Earth Telescope (WET; Nather et al. 1990) campaign XCov 18 in 1999 November and XCov 20 in 2000 November.

We observed ZZ Ceti extensively on the 0.9 and 2.1 m telescopes at McDonald Observatory in 1999 and 2000 with P3Mudgee, a three-star photometer (Kleinman, Nather, & Phillips 1996). In 2001 November, we also acquired high signal-to-noise data by using our new prime-focus CCD photometer, Argos, at the 2.1 m telescope (Nather & Mukadam 2003). This instrument on the 2.1 m telescope has an efficiency equivalent to P3Mudgee on a 6 m telescope. Our observations extend the time base on ZZ Ceti by 8 years, increasing it to a total time span of 31 years. Our

TABLE 1
DOMINANT MODES IN ZZ CETI (R548)

Period (s)	Amplitude (mma)[a]
213.1326	6.7
212.7684	4.1
274.2508	4.1
274.7745	2.9

[a] One millimodulation amplitude (mma) equals 0.1% change in intensity.

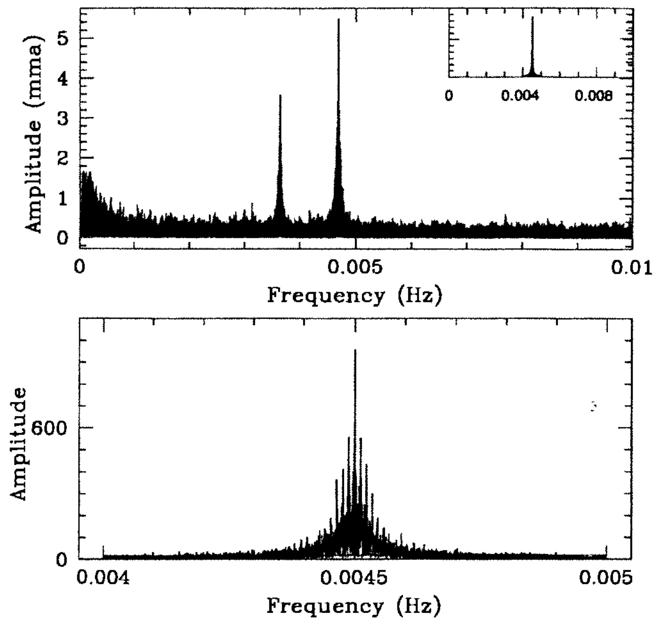

FIG. 1.—*Top*, Fourier transform (FT) of the data on ZZ Ceti from 1999; *bottom*, window pattern, what a single frequency in that data set should look like on an expanded scale; *top inset*, window pattern at the same scale as the FT.

journal of observations for all the data from 1999 to 2001 is published in Table 1 of Mukadam et al. (2003).

The dominant power in the pulsational spectrum of ZZ Ceti resides in two doublets at 213 and 274 s (Stover et al. 1980; Tomaney 1987) with a spacing of 0.5 s (see Table 1). In our experience, better timing is obtained for as small an integration time as is feasible; we found an integration time of 5 s to be ideal for P3Mudgee on the 0.9 m telescope, and 3 s for Argos on the 2.1 m telescope at McDonald Observatory. This sets the Nyquist frequency at 0.1 Hz, well beyond the range of the observed pulsation spectrum (Kepler et al. 1982). We did not use a filter with the blue-sensitive three-star photometer to maximize the signal-to-noise ratio; we used a BG 40 Schott glass filter with Argos.[45] This does not constitute a problem as the nonradial g-mode pulsations have the same phase in all colors (Robinson, Kepler, & Nather 1982; Nitta et al. 1999).

3. DATA REDUCTION

We reduced and analyzed the data in a manner described by Nather et al. (1990) and Kepler (1993), correcting for extinction and sky variations. After this preliminary reduction, we brought the data to the same fractional amplitude scale and converted the times of arrival of photons to barycentric coordinated time (TCB; Standish 1998). We computed a Fourier transform (FT) for all the data sets. Figure 1 shows our best FT from multisite and extensive single-site observations of ZZ Ceti in 1999.

4. DATA ANALYSIS

Before a $\dot{P}$ measurement can prove meaningful toward determining a cooling rate, we require that the dominant modes in the star do not strongly interact with each other, have stable amplitudes, and are well resolved in the data. We make a critical assumption: we assume that the star does the same thing when we are not looking as when we are.

We used three different techniques to determine $\dot{P}$: direct method, $O-C$ diagram, and the direct nonlinear least-squares approach. The doublets were clearly resolved in seasonal observations in the years 1970, 1975, 1980, 1986, 1991, 1993, 1999, and 2000; they are just barely resolved in 2001. The 1991 data set spans only 5 days and is our shortest season. Most seasons span over a month, and hence their phases are more reliable. We used only the above listed seasons from all our data spanning 1970–2001 for the direct method (§ 4.1) and the $O-C$ diagram (§ 4.2). We were able to utilize all our data for the nonlinear least-squares technique (§ 4.3).

4.1. *Direct Method*

The brute-force direct method consists of plotting the best period for each individual season versus time and equating the best-fit slope to a constraint on the value of $\dot{P}$, as shown in Figures 2 and 3. To obtain these seasonal values, we fit both periods of the doublets simultaneously using a nonlinear least-squares program. The true uncertainties in these values are larger than the formal nonlinear least-squares uncertainties due to pattern and alias noise. Alias noise is caused by the finite extent of the data and the gaps in them and is non-Gaussian in nature. Alias noise can be reduced by multisite observations using instruments such as the WET, which consists of a collaboration of observatories around the globe, and can observe a given pulsator for 24 hr per day. Pattern noise has an underlying structure and is also non-Gaussian (Schwarzenberg-Czerny 1991, 1999). The two frequencies in the doublets are closely spaced; one frequency represents a source of non-Gaussian noise while determining the phase, period, and amplitude for the other. We can decrease pattern noise by increasing the time span of observations, thereby better resolving the doublets.

Our best seasonal periods are shown in Tables 2 and 3, along with their uncertainties. Our linear least-squares fit, shown in the plot in Figure 2, yields $\dot{P} = (0.5 \pm 2.4) \times 10^{-13}$ s s^{-1} for $P_0 = 213.13245 \pm 0.00009$ s and $\dot{P} = (10 \pm 10) \times 10^{-13}$ s s^{-1} for $P_0 = 212.7694 \pm 0.0004$ s. Figure 3 shows a plot of the best periods for the 274 s doublet versus

[45] Amplitudes can be underestimated by as much as 20% for a DAV (Kanaan et al. 2000) if we use a red-sensitive photo tube or a CCD to acquire the data. We have to use a filter (e.g., BG 18, BG 38, BG 39, or BG 40 glass) with red-sensitive detectors to suppress the red part of the spectrum and to measure amplitudes reliably. This reduces the photon count but yields amplitudes comparable to blue-sensitive bi-alkali photomultipliers.

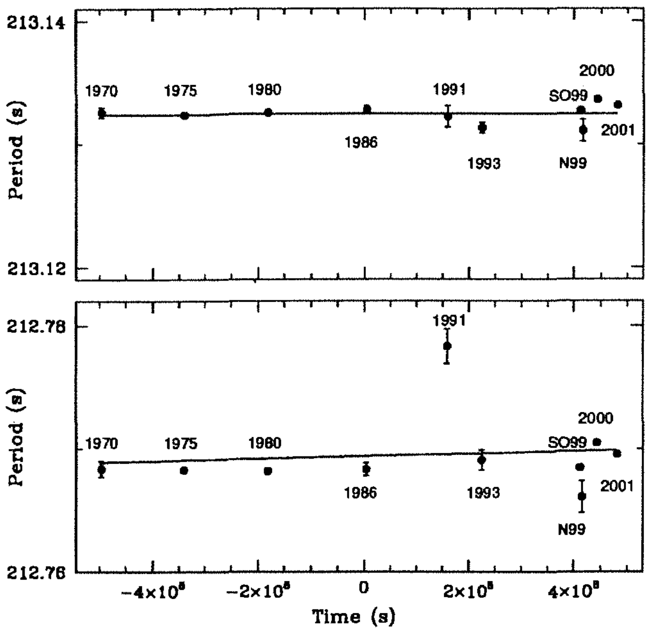

FIG. 2.—Direct method: best seasonal periods vs. time for the 213 s doublet, useful in ruling out large values of $\dot{P}$. *Top*, Best-fit $\dot{P} = (0.5 \pm 2.4) \times 10^{-13}$ s s^{-1} for $P_0 = 213.13245 \pm 0.00009$ s; *bottom*, best-fit $\dot{P} = (10 \pm 10) \times 10^{-13}$ s s^{-1} for $P_0 = 212.7694 \pm 0.0004$ s. The 1991 data set spans over 5 days and contains only 21 hr of data, while other seasons span over a month on average.

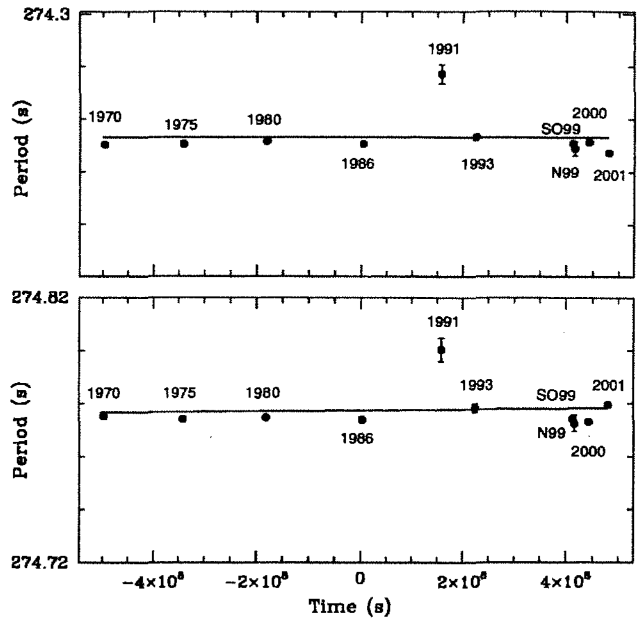

FIG. 3.—Direct method: best seasonal periods vs. time for the 274 s doublet. *Top*, Best-fit $\dot{P} = (-0.4 \pm 27) \times 10^{-13}$ s s^{-1} for $P_0 = 274.253 \pm 0.001$ s; *bottom*, best-fit $\dot{P} = (16 \pm 26) \times 10^{-13}$ s s^{-1} for $P_0 = 274.7774 \pm 0.0009$ s.

TABLE 2

$O - C$ VALUES

$O - C$ (s)	Error in $O - C$ (s)	Epoch	Season	Period (s)
1.4	3.7	−2,346,428	1970	213.13261 ± 0.00041
0.4	1.6	−1,617,531	1975	213.132403 ± 0.000093
1.0	2.4	−862,740	1980	213.13256 ± 0.00014
0.0	2.8	0	1986	213.13277 ± 0.00035
8.3	1.2	743,874	1991	213.13226 ± 0.00087
3.7	1.0	1,049,404	1993	213.13132 ± 0.00042
8.3	1.2	1,924,342	1999 Sep–Oct	213.13275 ± 0.00011
7.2	1.5	1,949,381	1999 Nov	213.13112 ± 0.00091
8.9	1.3	2,067,847	2000	213.13363 ± 0.00017
11.0	2.3	2,248,169	2001	213.133141 ± 0.000071

NOTE.—For period $P = 213.13260456 \pm 0.00000041$ s and $\dot{P} \leq (6.1 \pm 3.1) \times 10^{-15}$ s s^{-1}.

TABLE 3

$O - C$ VALUES

$O - C$ (s)	Error in $O - C$ (s)	Epoch	Season	Period (s)
−0.2	5.8	−2,350,444	1970	212.76835 ± 0.00066
3.5	2.6	−1,620,300	1975	212.76826 ± 0.00015
2.7	3.7	−864,217	1980	212.76817 ± 0.00022
0.0	4.2	0	1986	212.76833 ± 0.00054
2.2	1.8	745,148	1991	212.7783 ± 0.0014
−0.9	1.7	1,051,200	1993	212.76907 ± 0.00082
2.1	1.6	1,927,636	1999 Sep–Oct	212.76849 ± 0.00015
1.5	2.0	1,952,718	1999 Nov	212.7661 ± 0.0013
−1.6	1.7	2,071,386	2000	212.77047 ± 0.00025
5.8	2.3	2,252,017	2001	212.769556 ± 0.000068

NOTE.—For period $P = 212.76842927 \pm 0.00000051$ s and $\dot{P} \leq (1.2 \pm 4.0) \times 10^{-15}$ s s^{-1}.

time. We obtain $\dot{P} = (-0.4 \pm 27) \times 10^{-13}$ s s^{-1} for $P_0 = 274.253 \pm 0.001$ s and $\dot{P} = (16 \pm 26) \times 10^{-13}$ s s^{-1} for $P_0 = 274.7774 \pm 0.0009$ s.

This brute-force technique is not very sensitive to determine $\dot{P}$, but it is absolutely essential in ruling out incorrect solutions that may seem just as likely from the more sensitive techniques, the $O-C$ diagram and the direct nonlinear least-squares approach. Both these techniques suffer from cycle count errors between data sets (explained in the next subsection), while the direct method is independent of this error. The uncertainties in the $\dot{P}$ values we obtained for both the doublets prove to be constructive limits in ruling out large changes in period over time.

4.2. *O−C Technique*

The $O-C$ technique (e.g., Kepler et al. 1991) can be used to improve the period estimates for any periodic phenomenon. The O stands for the observed value of the time of maximum (or time of zero) for a cycle or an epoch E that occurs in a data set. The C stands for its calculated value or ephemeris. If $O-C$ values show a linear trend, then the slope indicates a correction to the period. On the other hand, a nonlinear trend in the $O-C$ diagram shows that the period is changing.

We use bootstrapping (Winget et al. 1985) to improve the period and to extend our phase baseline from one observing season to the next available one. Bootstrapping assumes that we know the period precisely enough to predict the phase for the next data set without cycle count ambiguities. As we know that the uncertainties in phase from the least-squares program are underestimated (Winget et al. 1985; Costa, Kepler, & Winget 1999; Mukadam 2000), we checked for cycle errors up to $E \pm 2$. Larger cycle count errors are ruled out by limits from the direct method.

4.2.1. *Results from the O−C Technique*

Our $O-C$ values for the 213 s doublet are plotted in Figure 4 and presented in Tables 2 and 3, along with the best period and $\dot{P}$ values. The zero epoch corresponds to a reference time of maximum (E_0) of 2,446,679.833986 TCB. We obtain $\dot{P} \leq (6.1 \pm 3.1) \times 10^{-15}$ s s^{-1} for the period $P = 213.13260456 \pm 0.00000041$ s. We also found $\dot{P} \leq (1.2 \pm 4.0) \times 10^{-15}$ s s^{-1} for the period $P = 212.76842927 \pm 0.00000051$ s. The $\dot{P}$ values are comparable to their uncertainties and should be thought of as upper limits only. The $\dot{P}$ values for both modes of the 213 s doublet are consistent with $\dot{P}$ measurements for G117-B15A and detailed theoretical evolutionary models. We conclude that these values constrain the evolution of ZZ Ceti.

The $O-C$ diagram for the 274 s doublet shows changes on a timescale that is 100 times faster than the 213 s doublet. This makes the same gaps between data sets too large to determine the cycle counts. As we have already constrained the cooling rate with the 213 s doublet, we can conclude that the $O-C$ diagrams for both modes of the 274 s doublet are not indicative of cooling. Possible short-term variations in phase on the order of a few months to a few years could be swamping out the parabolic effect of the cooling. These modes may be subject to other effects, such as trapping and avoided crossings (Wood & Winget 1988; Brassard et al. 1992; Montgomery 1998; Benvenuto et al. 2002), discussed in § 6.2. Mukadam (2000) contains a table of $O-C$ values for the 274 s doublet.

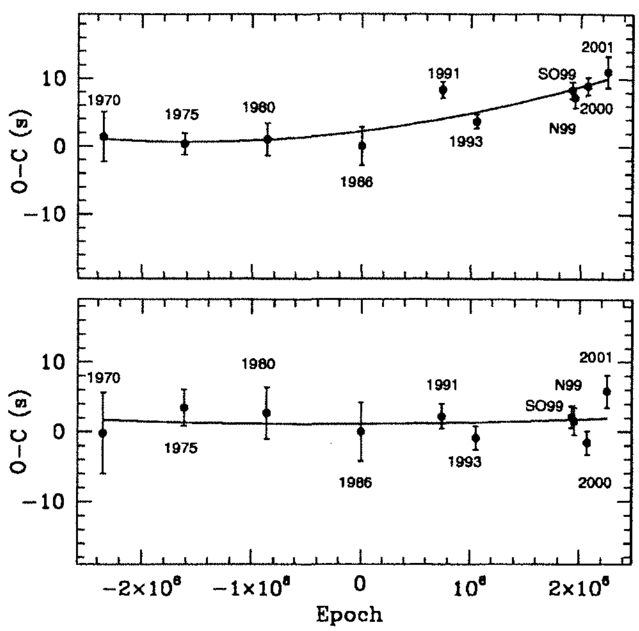

FIG. 4.—*Top*, $O-C$ plot for the 213.13260456 s period, with the best-fit parabola $\dot{P} \leq (6.1 \pm 3.1) \times 10^{-15}$ s s^{-1} drawn as a continuous line; *bottom*, $O-C$ diagram for the period 212.76842927 s with the best fit of $\dot{P} \leq (1.2 \pm 4.0) \times 10^{-15}$ s s^{-1}. The 1991 data set spans only 5 days and is our shortest season. Most seasons span over a month, and hence their phases are more reliable.

4.3. *Direct Nonlinear Least-Squares Fit*

We can fit a variable period to all the data from 1970 to 2001 by using a nonlinear least-squares program to obtain a reliable $\dot{P}$. We fit both periods of the doublet simultaneously to all the data from 1970 to 2001. The program utilizes period, phase, amplitude, and a guess value for $\dot{P}$ as inputs. We fix the amplitude for both periods, optimizing the remaining parameters to minimize the residuals, obtaining a reliable $\dot{P}$ value based on all the data points from 1970 up to 2001. An advantage of this technique over the $O-C$ method is that we can now include all the data in a combined light curve, whether or not the doublets are resolved in individual seasons. These techniques are not completely independent. This technique also suffers from cycle count errors in gaps between data sets, just like the $O-C$ method; when we input a guess value for $\dot{P}$ along with a period, we are effectively feeding in cycle counts for the various epochs; the same bootstrapping process is implicitly applied here.

We obtain $\dot{P} \leq (7.7 \pm 1.9) \times 10^{-15}$ s s^{-1} for $P = 213.132605 \pm 0.000001$ s and $\dot{P} \leq (2.9 \pm 2.8) \times 10^{-15}$ s s^{-1} for $P = 212.768429 \pm 0.000001$ s. The results for the nonlinear least-squares fit are clearly consistent with the $O-C$ technique for both periods within their uncertainties. We do not claim either of these values to be measurements because we have seen them fluctuate with the addition of subsequent seasons; they are not yet reliable as measurements, but they are useful and reliable as constraints.

5. BEST VALUE OF $\dot{P}$ FOR ZZ CETI

We used the $\dot{P}$ limits from the direct method to rule out large changes in the period with time for both doublets. We conclude from the results of the more sensitive techniques, the $O-C$ diagram and the nonlinear least-squares approach, that the $\dot{P}$ values for the 213 s doublet reflect cooling of the star, while the values for the 274 s doublet do not. This is because evolutionary cooling is expected to be one of the slowest changes, and the 274 s doublet seems to evolve at least 100 times faster than the 213 s doublet. For the context of this paper, we will henceforth discuss only the 213 s doublet as we had set out to measure the cooling rate of the star.

The uncertainties in $\dot{P}$ for both the $O-C$ technique and the nonlinear least-squares method decrease as time-square goes by. The $O-C$ technique uses the seasonal data to obtain the best value for the first time of maximum. These well-determined values then contribute toward finding the optimal solution for $\dot{P}$. The nonlinear least-squares technique utilizes all the points in a data set and therefore directly incorporates all the times of maxima. This increases the reliability of the $\dot{P}$ value; hence, we quote the nonlinear least-squares fits as our best values for the 213 s doublet: $\dot{P} \leq (7.7 \pm 1.9) \times 10^{-15}$ s s^{-1} for $P = 213.132605$ s and $\dot{P} \leq (2.9 \pm 2.8) \times 10^{-15}$ s s^{-1} for $P = 212.768429$ s. The 213.132605 s period has an amplitude of about 6.2 millimodulation amplitude (mma), while the 212.768429 s period is about 4.1 millimodulation mma. The smaller uncertainty in the $\dot{P}$ measurement for $P = 213.132605$ s is clearly a manifestation of larger amplitude and consequently better signal-to-noise ratio, as compared with $P = 212.768429$ s. Therefore the value of $(7.7 \pm 1.9) \times 10^{-15}$ s s^{-1} better reflects the constraining upper limit on $\dot{P}$ for ZZ Ceti.

Tomaney (1987) published his best value, $\dot{P} < (0.4 \pm 9.6) \times 10^{-15}$ s s^{-1}, for the 213 s doublet. This implies that at the 3 σ level his upper limit for the rate of cooling was effectively 29.2×10^{-15} s s^{-1}. Our results are a further refinement due to the larger time base, and they are consistent with previous results.

We claim $\dot{P} \leq (7.7 \pm 1.9) \times 10^{-15}$ s s^{-1} as an upper limit and not as a true measurement. We found fluctuations in the $\dot{P}$ value as we added various seasons of observation, but the uncertainty in $\dot{P}$ always monotonically decreased. This is true for G117-B15A as well and is clearly indicated in Table 1 from Kepler et al. (2000). This leads us to conclude that the uncertainties are true indicators of reliability and are currently more significant than the $\dot{P}$ values. If we determine consistent $\dot{P}$ values for at least three consecutive seasons, then we will believe that it is a measurement and not a constraint. As the $\dot{P}$ for $P = 213.132605$ s is an upper limit, we can conclude that $\dot{P} \leq (2.9 \pm 2.8) \times 10^{-15}$ s s^{-1} for $P = 212.768429$ s is consistent with it. In all subsequent considerations, we will use as our best value $\dot{P} \leq (7.7 \pm 1.9) \times 10^{-15}$ s s^{-1}.

5.1. *Correction Due to Proper Motion*

Pulsating white dwarfs have a nonevolutionary secular period change due to proper motion. Pajdosz (1995) estimated the size of this effect to be on the order of 10^{-15} s s^{-1}. This proper-motion correction to $\dot{P}$ is insignificant for the DOV and PNNV stars because their evolutionary $\dot{P}$ is several orders of magnitude larger. However, it is of the same order as the $\dot{P}$ measured for hot DAVs such as ZZ Ceti and G117-B15A. Pajdosz (1995) demonstrates that the correction is always positive and must be subtracted from $\dot{P}_{obs}$. Using $\mu = 0\farcs236$ yr^{-1} and $\pi = 0\farcs013$ (Harrington & Dahn 1980), we evaluate $\dot{P}_{pm}$ for the four periods along with their respective uncertainties, both of which have been indicated in Table 4. Subtracting out $\dot{P}_{pm}$, we have the following best limit: $\dot{P}_{cool} \leq (5.5 \pm 1.9) \times 10^{-15}$ s s^{-1} for ZZ Ceti.

TABLE 4
CORRECTION IN $\dot{P}$ DUE TO PROPER MOTION

Period (s)	$\dot{P}_{pm}$ (10^{-15} s s^{-1})	$\sigma_{\dot{P}_{pm}}$ (10^{-15} s s^{-1})
213.132605	2.22	0.36
212.768429	2.22	0.36
274.250804	2.86	0.46
274.774501	2.86	0.46

6. INTERPRETATION OF THE RESULTS

6.1. *Stability of the* 213 s *Doublet*

Using our best limit for the 213 s doublet, $\dot{P} \leq (5.5 \pm 1.9) \times 10^{-15}$ s s^{-1}, we calculate the evolutionary timescale $| P/\dot{P} | \geq 1.2$ Gyr. We compute $\tau_s \geq 0.9$ Gyr and $\tau_s \geq 0.6$ Gyr at the 1 σ and 3 σ levels, respectively.[46] Theoretical models suggest that the 213 s doublet in ZZ Ceti should show a $\dot{P}$ value in the range (2–6) $\times 10^{-15}$ s s^{-1} (e.g., Bradley et al. 1992; Bradley 1996). Our limit is consistent with theoretical calculations of cooling, as well as the $\dot{P}$ measurement for G117-B15A, and is already a constraint on stellar evolution.

The hot DAV stars, which include ZZ Ceti, are expected to exhibit extreme frequency stability, making them reliable clocks. We found this to be true for the 213 s doublet. Theory tells us that this frequency stability may be associated with two different effects: low radial overtone (k) modes and mode trapping. Low k-modes sample the deep interior and have a rate of period change that reflects the global cooling timescale alone. High k-modes have regions of period formation farther out in the star and so may be more easily affected by magnetic fields, rotation, convection, and nonlinear interactions. ZZ Ceti has a measured magnetic field upper limit of about 20 kG (Schmidt & Grauer 1997).

Compositional stratification occurs in white dwarf stars because of gravitational settling and prior nuclear shell burning. A mechanical resonance is induced between the local g-mode oscillation wavelength and the thickness of one of the compositional layers (Winget, Van Horn, & Hansen 1981). This mechanical resonance serves as a stabilizing mechanism in model calculations. For a mode to be trapped in the outer H layer, it needs to have a resonance with the He/H transition region such that its vertical and horizontal displacements both have a node near this interface (Brassard et al. 1992; Montgomery 1998). Note that the H/He interface can also lead to confinement or trapping of modes in the core. Trapped modes are energetically favored, as the amplitudes of their eigenfunctions below the H/He interface are smaller than untrapped modes. Modes trapped in the envelope can have kinetic oscillation energies lower by a few orders of magnitude, compared with the adjacent

[46] To calculate these limits, we cannot use the differential approach as the uncertainties in $\dot{P}$ are comparable to the value itself. We calculate a 1 σ limit from the expression $P/(| \dot{P} | + \sigma_{\dot{P}})$ and a 3 σ limit from $P/(| \dot{P} | + 3\sigma_{\dot{P}})$.

nontrapped modes (Winget et al. 1981; Brassard et al. 1992). Benvenuto et al. (2002) claim a marked weakening of mode-trapping effects with a time-dependent element diffusion in the DA white dwarf models with different thicknesses of the hydrogen envelope.

The resonance condition changes as the star cools, and this can lead to an avoided crossing, as explained in § 6.2. As a DAV cools within the instability strip, trapped modes spend about a quarter of their time in an avoided crossing, during which they are expected to indicate a larger $\dot{P}$ than due to cooling. The trapped modes are stable only for three quarters of the total time spent in the instability strip, when they are not undergoing an avoided crossing. During that time, they evolve more slowly than untrapped modes by a factor ≥ 2 (Bradley et al. 1992; Bradley 1993). Modes of differing k sample slightly different regions in the star with correspondingly different evolutionary timescales; hence, we expect each mode to have a slightly different rate of period change (Wood & Winget 1988).

All the hot DAV stars known are low k-pulsators, including ZZ Ceti. Bradley (1998) identified the 213 s doublet as $l = 1$, $k = 2$. This suggests that the stability of the modes can be partially attributed to their low k-values, as explained earlier. However, low k-modes can also be trapped. If the 213 s doublet in ZZ Ceti consists of trapped modes, then indeed our subsequent measurement of the $\dot{P}$ will reflect the stability of the trapping mechanism, which is related to the cooling rate. Presently, we have only an upper limit for $\dot{P}$, and we cannot conclude whether these modes are trapped.

We expect the uncertainties in measuring $\dot{P}$ to decrease as the square of the time base.[47] This implies that if we continue acquiring data with the same telescopes and PMT photometers, we would need 95 years of data to reduce the uncertainties by a factor of 10. However, with our new higher quantum efficiency CCD photometer, we get the same signal-to-noise ratio as the PMT photometer on a 6 m telescope (Nather & Mukadam 2003). If we acquire longer data sets with CCD photometers, use larger telescopes, or make a combination of both every few years, then we could achieve a significant reduction in the uncertainties in a shorter time span.

6.2. *Summary of Results for the* 274 s *Doublet*

The implied $\dot{P}$ from the $O-C$ diagram for the 274 s doublet is 100 times larger than the $\dot{P}$ for the 213 s doublet. Long-term limits from the direct method in § 4.1 indicate that $|\dot{P}| \sim 3 \times 10^{-12}$ s s^{-1} for the 274 s doublet. The minimum dispersion in the $O-C$ diagram, which does not fit a parabola, allows us to set a lower limit $\Delta P/\Delta t \approx 10^{-13}$ s s^{-1} for the long-term behavior. We do not know yet what this period variation entails, but we know that it is not consistent with cooling, as cooling is the slowest of all possible timescales. For both modes of the 274 s doublet, we could never achieve a clear minimization of phase dispersion. The uncertainties in phase are larger for the 274 s doublet as it has a lower amplitude compared with the 213 s doublet, but not low enough to explain away the discrepancies. We

[47] Kepler et al. 2000 find that the uncertainties decrease linearly with time for G117-B15A. However, this may possibly be associated with the observed 1.8 s scatter (Kepler et al. 2000 and references therein).

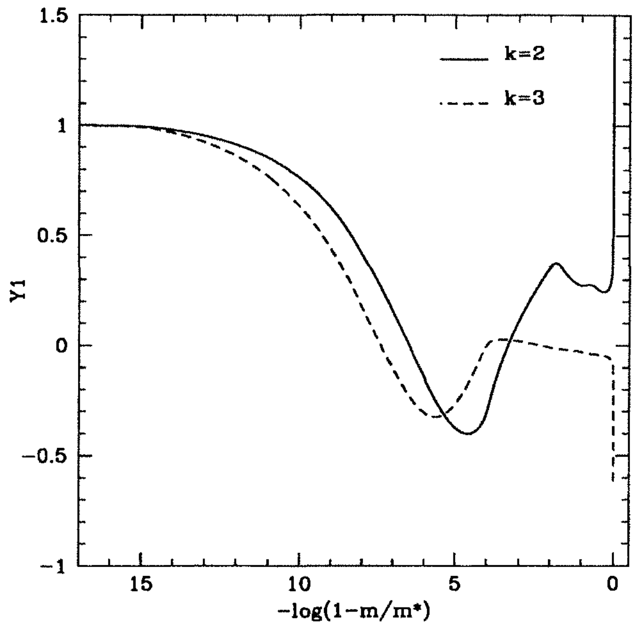

FIG. 5.—Radial perturbation ($Y_1 = \delta r/r$) for the best model of ZZ Ceti calculated by Bradley (1998), showing eigenfunction for the $k = 3$ mode. This mode corresponds to the 274 s periodicities and has negligible amplitude from the center [$\log(1 - M/M_*) = 0$] to the envelope [$\log(1 - M/M_*) \leq 4$] compared with the $k = 2$ mode, which corresponds to the 213 s periodicities.

obtain an $O-C$ diagram with ambiguous cycle counts, and all the points do not lie on a parabola within the uncertainties. This suggests that $\dot{P}$ for the 274 s doublet is not constant and perhaps $\ddot{P}$ and/or higher order terms are significant.

We should remind ourselves that the two doublets sample different regions of the star. Bradley (1998) calculated nonradial perturbations for the best model of ZZ Ceti, given by $T_{\rm eff} = 12{,}420$ K, $M_* = 0.54\ M_\odot$, hydrogen layer mass $M_{\rm H} = 0.00015 M_*$, helium layer mass $M_{\rm He} = 0.015 M_*$, and ML3 convection. The eigenfunctions for the $l = 1$, $k = 3$ mode or the 274 s doublet show negligible amplitude near the center of the star compared with the $l = 1$, $k = 2$ mode, which corresponds to the 213 s doublet. This is clearly indicated in Figure 5. It is possible that the 274 s doublet has a larger $\dot{P}$ because it samples regions of the star that could be undergoing changes on timescales shorter than the evolutionary timescale.

An avoided crossing, described below, represents another explanation for the 274 s doublet. Wood & Winget (1988) carried out pulsation calculations in the quasi-adiabatic Cowling approximation for $l = 2$, $k = 1, \ldots, 16$. They evolved their models from 13,000 to 11,000 K across the DAV instability strip. Figures 1 and 2 in their paper clearly show $k = 6$ as the trapped mode at the hot end of the sequence. As the star cools, the kinetic energies of the $k = 5$ and $k = 6$ modes pull closer together. At this point, the physical properties of the two modes become nearly identical, and they become indistinguishable from the driving mechanism. As the models continue to evolve, $k = 5$ becomes the new trapped mode. These modes have effectively interchanged their nature, and this phenomenon is known as an avoided crossing (Aizenman, Smeyers, & Weigert 1977; Christensen-Dalsgaard 1981). Of the 16 modes, four were computed to undergo such an avoided crossing, i.e., one of every four modes may be expected to undergo an avoided crossing.

Stable modes can become unstable during an avoided crossing (Wood & Winget 1988; Montgomery & Winget 1999), as explained in § 6.2. In other words, if we were monitoring the $\dot{P}$ for any of these modes, we would observe a rapid change during the crossover; i.e., the $\ddot{P}$ term would be important. Montgomery & Winget (1999) have done the most detailed calculation to date, showing how the g-mode periods evolve as the crystallized mass fraction is slowly increased. Their results, plotted in Figure 9 of their paper, clearly show many kinks or avoided crossings. Wood & Winget (1988), as well as Bradley & Winget (1991), saw similar behavior in their evolutionary calculations, when they included H and He layers in their models. The 274 s doublet in ZZ Ceti could be undergoing an avoided crossing, but this issue needs to be investigated more thoroughly.

Possibly the 274 s doublet is undergoing other short-term phase variations,[48] perhaps associated with the presence of nearby undetected modes, that have been successful in swamping out the cooling effect. Variations in $\dot{P}$ at short timescales on the order of a few months to a few years, superposed on the secular cooling (Dziembowski & Koester 1981), that average out over 30 years could explain the partial stability that we see. However, such short-term phase variations could render a parabolic fit to the $O-C$ diagram difficult, thus swamping out changes in period due to cooling. We cannot place any limits on the short-term behavior, as we have large gaps between data sets.

We hope to attempt to unravel this mystery by obtaining additional multisite and extensive single-site data for an additional 6 or 7 years. As both the 213 s doublet in ZZ Ceti and the 215 s mode in G117-B15A show a similar $\dot{P}$, it would be worthwhile to find out whether the 270 s mode in G117-B15A behaves like the 274 s doublet in ZZ Ceti.

7. ADDITIONAL PULSATION MODES

Our FTs from the various seasonal data sets showed additional pulsations around 187.27, 318.08, and 333.65 s. Observations of ZZ Ceti with the 3.6 m CFHT in 1991 clearly revealed these modes, though the result remained unpublished till now. An FT of the 1991 data set, after prewhitening or removing the two doublets, is shown in Figure 6. We can clearly see the new modes along with the residual amplitude of the two doublets left behind in the prewhitening process.[49] Table 5 gives our best estimates for the periods and amplitudes for the various years of observation. The amplitudes of these modes are small enough that determining their precise frequencies is difficult.

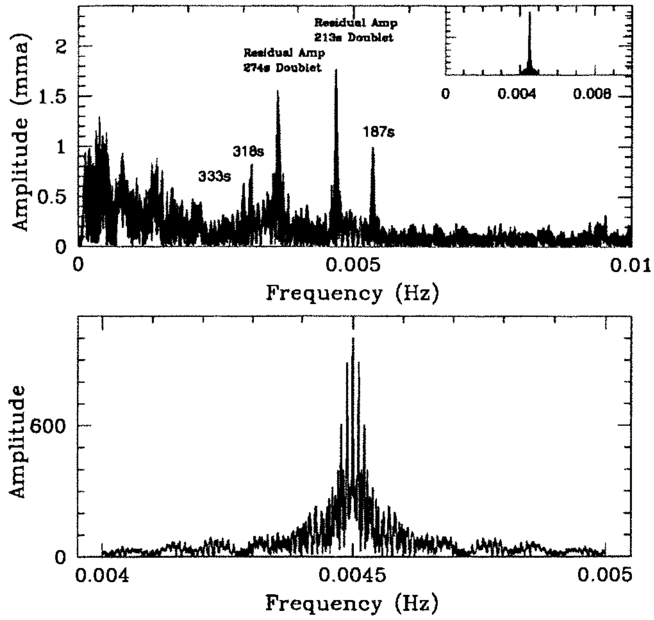

FIG. 6.—*Top*: Prewhitened FT of the 1991 data set, clearly showing the additional modes 187, 318, and 333 s. The doublets were not prewhitened completely, and some residual amplitude is left behind. *Bottom*: Window pattern.

With the discovery of three additional modes in ZZ Ceti, we now have five modes with different l and k values. Bradley (1998) pointed out various feasible mode identifications for the pulsation periods observed in ZZ Ceti (see his § 5.6). The confirmation of the 187, 318, and 333 s modes suggest that the 213 and 274 s doublets (caused by

[48] We have searched for variations in phase at timescales from a few days to a month or so and found none.

[49] Prewhitening of individual seasons leaves behind some residual amplitude, which can be interpreted as a third frequency with an amplitude ≤ 2 mma, implying that the 213 and 274 s modes are actually triplets and not doublets. We prewhitened various seasons with the two known periods at 213 and 274 s and then attempted to determine the third frequency by using a nonlinear least-squares fit to the residual amplitude. We obtained different frequencies with differing amplitudes from the various seasons. This implies that from the quality of data in hand we can neither conclude that we have a triplet nor rule it out. To resolve this issue, we need very high signal-to-noise data for at least three seasons, which clearly shows evidence of the triplet even without prewhitening; frequencies determined from prewhitening alone are not reliable. Other causes of the residual amplitude could include timing uncertainties of individual runs in a season and/or amplitude changes.

TABLE 5

PERIOD AND AMPLITUDE MEASUREMENTS FOR THE ADDITIONAL PULSATION MODES

Season	Period (s)	Amplitude (mma)	Period (s)	Amplitude (mma)	Period (s)	Amplitude (mma)
1991	333.636 ± 0.015	0.64 ± 0.08	318.049 ± 0.011	0.85 ± 0.08	187.272 ± 0.003	0.93 ± 0.08
1993	...	...	...	...	187.267 ± 0.002	0.85 ± 0.13
1999 Sep–Oct	333.642 ± 0.004	0.51 ± 0.16	318.075 ± 0.002	0.93 ± 0.16	...	...
1999 Nov	333.634 ± 0.010	1.31 ± 0.17	318.082 ± 0.015	0.82 ± 0.17	...	...
2000	333.668 ± 0.004	0.67 ± 0.15	318.080 ± 0.003	0.67 ± 0.15	...	...
2001	333.639 ± 0.001	1.03 ± 0.13	318.074 ± 0.001	1.10 ± 0.13	187.286 ± 0.001	0.43 ± 0.12

rotational splitting) are probably $l = 1$, $k = 2$ and $l = 1$, $k = 3$ modes, respectively (Bradley 1998). He shows that models with this mode identification have periods that best match the newly identified modes. The three new modes are most likely $l = 2$ modes with $k = 4$, $k = 8$, and $k = 9$ (Bradley 1998). This mode identification also suggests that ZZ Ceti has a mass near 0.54 $M_{\odot}$, a 65%–80% oxygen core, a hydrogen layer mass of $0.00015M_*$, and a helium layer mass near $0.015M_*$ (Bradley 1998). Bergeron et al. (1995) determined an effective temperature $T_{\rm eff} = 11{,}990$ K, $\log g = 7.97$, and a mass of 0.59 $M_{\odot}$ from high signal-to-noise optical spectrophotometry data on ZZ Ceti by using new model atmospheres.

8. IMPLICATIONS AND APPLICATIONS

White dwarf cosmochronometry.—Some of the theoretical uncertainty in using white dwarfs as chronometers to constrain the age of the Galactic disk (e.g., Winget et al. 1987) and the halo (e.g., Hansen et al. 2002) can be reduced by calibrating the white dwarf cooling curve. This involves empirical measurements of the cooling rates of white dwarfs at different temperatures. Our upper limit on the rate of cooling of ZZ Ceti already constrains theoretical evolutionary models. Our constraint along with the $\dot{P}$ measurements for PG 1159-035 (Costa et al. 1999) and G117-B15A (Kepler et al. 2000) helps in calibrating the white dwarf cooling curve.

Core composition.—The rate of cooling of a white dwarf depends mainly on core composition and stellar mass. For a given core mass, a larger mean atomic weight will correspond to fewer nuclei with smaller heat capacity, resulting in more rapid cooling. By constraining the rate of cooling for ZZ Ceti and comparing it with theoretical evolutionary models, we effectively limit the mean atomic weight of the core. Bradley et al. (1992) obtained theoretical $\dot{P}$ values around $(5\text{–}7) \times 10^{-15}$ s s^{-1} from detailed calculations for untrapped modes in oxygen core 0.5 $M_{\odot}$ models with periods close to 215 s. Panei, Althaus, & Benvenuto (2000) find that models with a pure iron core cool faster than their carbon-oxygen counterparts up to a factor of 5. This implies that our current limit of 5.5×10^{-15} s s^{-1} indicates a carbon-oxygen core and eliminates substantially heavier cores, as they would produce a faster rate of period change than observed.

Stable clock.—ZZ Ceti is the second most stable optical clock known. Moreover, the drift in this clock is unidirectional and predictable as it is caused by cooling of the star. This characteristic makes clocks such as ZZ Ceti and G117-B15A comparable to atomic clocks and better than most pulsars. Atomic clocks demonstrate an uncertainty in phase that is best described as a random walk, while many pulsars are known to have an inherent noise level on the order of 10^{-14} s s^{-1} (Kaspi, Taylor, & Ryba 1994), in addition to star quakes that cause glitches. The millisecond pulsar PSR B1885+09, however, is more stable than both ZZ Ceti and G117-B15A. It has a period of 5.36 ms and a measured $\dot{P} = 1.78363 \times 10^{-20}$ s s^{-1} (Kaspi et al. 1994), which implies that the stability timescale is $\tau_s \approx 9.5$ Gyr. We compute τ_s longer than 3.0 and 1.2 Gyr for G117-B15A and ZZ Ceti, respectively.

We note that G117-B15A and ZZ Ceti are stable enough to act as a reference for the atomic clock system that underpins the GPS network. National Institute of Standards and Technology (NIST) claims an uncertainty of 2×10^{-15} for NIST-F1 (Bergquist, Jefferts, & Wineland 2001), the cesium fountain atomic clock, which defines the most accurate primary time and frequency standard to date. We compute $\tau_s = 15.1$ hr for the clock.

Orbital companion.—A stable clock with an orbital companion will revolve around the center of mass of the system, thus changing the light travel time of the pulse maxima. The variable period resulting from the orbital motion of the clock will cause a $\dot{P}_{\rm orb}$ (Kepler et al. 1991), the amplitude of which is the orbital light travel time.

Detection of an orbital companion around a pulsating white dwarf depends on the following parameters: the mass m of the companion and the inclination angle i ($\dot{P}_{\rm orb} \propto m \sin i$), its distance a from the white dwarf ($\dot{P}_{\rm orb} \propto 1/a^2$), and the orbital period T, all of which are not independent. The first two criteria are easy to understand; if the companion is not massive or far away from the white dwarf, then its gravitational influence may not be detectable. The third criterion is more subtle. When we observe pulsating white dwarfs, we do not directly measure $\dot{P}$. We infer a $\dot{P}$ by comparing our measurements of the phases with what we expect for a constant period, i.e., by using the $O-C$ technique. The phase difference, $O-C$, increases because of an orbital companion for half an orbital period, after which it must start decreasing. At the end of an orbital period, the $O-C$ must reflect a change from cooling alone. So, the phase variation amplitude in the $O-C$ diagram depends not only on the magnitude of $\dot{P}_{\rm orb}$ but also on the time for which the phase change was allowed to accumulate, i.e., $T/2$.

With this technique, it is easier to detect companions with large orbital periods, though that will necessarily require long-term observations. The phase changes are cumulative, and so in the limit of slow changes (long orbital periods) our limits improve as time-square goes by. Nearby planets with shorter orbital periods may be detected by decreasing the uncertainties on individual phase measurements.

The following examples demonstrate the sensitivity of this technique. An Earthlike planet orbiting ZZ Ceti at a distance of 1 AU will result in $\dot{P}_{\rm orb}^{\rm Earth} = 12.5 \times 10^{-15}$ s s^{-1} and a phase variation amplitude of a few milliseconds. Detection on Earth requires greater timing accuracy than current observations of ZZ Ceti and G117-B15A, even though $\dot{P}_{\rm orb}$ is more than twice as large as the evolutionary $\dot{P}$. Jupiter ($M = 318\ M_{\oplus}$) at 5.2 AU will result in $\dot{P}_{\rm orb} = 1.5 \times 10^{-13}$ s s^{-1} with an amplitude of 3–4 s. We can use our current detection limit of 1 s, constrained by our timing accuracy, to limit the mass and/or distance of any planetary companions around ZZ Ceti. Setting $\dot{P}_{\rm orb} = 5.5 \times 10^{-15}$ s s^{-1}, we are able to rule out planetary companions of masses $M \geq 38\ M_{\oplus}$ at distances $a \leq 9$ AU from ZZ Ceti.

Asteroseismology.—With the discovery of three additional modes in ZZ Ceti, we now have five known independent modes. This helps us in mode identification and leads to constraining the stellar structure through asteroseismology. It will also assist in the work on ensemble asteroseismology of DAVs (Kleinman, Kawaler, & Bischoff 2000). Metcalfe, Nather, & Winget (2000) have applied an optimization method utilizing a genetic algorithm for fitting white dwarf pulsation models to asteroseismological data. For the success of this technique, they require at least seven or eight observed modes. With the additional modes found in ZZ Ceti, coupled to the fact that it shows low-amplitude sinusoidal variations, it becomes an attractive candidate for such work.

9. CONCLUSION

We obtained extensive multi- and single-site data on ZZ Ceti, thereby increasing the existing time span of data by 8 years, to a total of 31 years. We applied the direct method on resolved seasons to help us rule out large changes in period over time. Confident of our limits from the direct method, we then searched in a narrow grid of solution space with two of the more sensitive techniques, the $O - C$ diagram and the nonlinear least-squares approach. We arrived at the best upper limit for the rate of period change for ZZ Ceti, $\dot{P} \leq (5.5 \pm 1.9) \times 10^{-15}$ s s^{-1}. This usefully constrains secular cooling, demonstrating an evolutionary timescale or stability timescale $|P/\dot{P}| \geq 1.2$ Gyr. We obtain a stability timescale $\tau_s \geq 0.9$ Gyr at the 1 σ level and $\tau_s \geq 0.6$ Gyr at the 3 σ level. Theoretical models suggest that the 213 s doublet in ZZ Ceti should show a $\dot{P}$ value in the range of (2–6) $\times 10^{-15}$ s s^{-1} (e.g., Bradley et al. 1992; Bradley 1996).

Limits from the direct method and the minimum dispersion in the $O - C$ diagram, which does not fit a parabola, allow us to set a lower limit $\Delta P/\Delta t \approx 10^{-13}$ s s^{-1} on the long-term behavior of the 274 s doublet. The implied limit does not reflect cooling, as cooling causes the slowest change in period with time, and is constrained by the 213 s doublet to be on the order of 10^{-15} s s^{-1}. The 274 s doublet, which samples a different region of the star than the 213 s doublet, may be undergoing an avoided crossing or other short-term phase variations, perhaps associated with the presence of nearby undetected modes. To investigate this issue, we need extensive single and multisite data for an additional 6–7 years.

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HIGH-PRECISION LIMB-DARKENING MEASUREMENT OF A K3 GIANT USING MICROLENSING

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ABSTRACT

We obtain high-precision limb-darkening measurements in five bands (V, V_E, I_E, I, and H) for the K3 III ($T_{\rm eff} = 4200$ K, [Fe/H] $= +0.3$, $\log g = 2.3$) source of the Galactic bulge microlensing event EROS BLG-2000-5. These measurements are inconsistent with the predictions of atmospheric models at higher than 10 σ. While the disagreement is present in all bands, it is most apparent in I, I_E, and V_E, in part because the data are better and in part because the intrinsic disagreement is stronger. We find that when limb-darkening profiles are normalized to have unit total flux, the I-band models for a broad range of temperatures all cross each other at a common point. The solar profile also passes through this point. However, the profile as measured by microlensing does not. We hypothesize that the models have incorporated some aspect of solar physics that is not shared by giant atmospheres.

Subject headings: gravitational lensing — stars: atmospheres

1. INTRODUCTION

The brightness profiles (limb darkenings) of stars are a potentially powerful probe of their atmospheres as a function of depth. At each point along the projected radius of a star, the observed flux originates from a range of physical depths, the deepest of which (the surface of last scattering) increases with projected physical radius as one's line of sight progresses from the center of the star toward its limb. Hence, since stellar temperatures generally fall towards the surface, one expects that the limb will appear cooler (and therefore redder and fainter) than the center. If model atmospheres accurately reflect the physical conditions of the star as a function of depth, they should reproduce the star's limb-darkening profile.

Because limb darkening is a photometric quantity, it can, in principle, be measured to high precision. The drawback is that one has to be able to determine where on the star the light is coming from. Historically, there are two ways this is done. The first is resolving the star. The most obvious example would be the Sun (Pierce & Waddell 1961). Recent advances in interferometry have allowed one to resolve the surfaces of the highest angular diameter stars (Burns et al. 1997) and have in recent years provided data good enough to begin challenging models (Wittkowski et al. 2001). The second method is by occultation, either by an object in our solar system or by one orbiting the observed star. The Moon is the only occulter used in our solar system. However, while lunar occultations are sufficiently precise to demonstrate that limb-darkened models are superior to uniform-brightness models, they lack the precision to test limb-darkening models. If the occulting body is in the source's system, it can be a star or a planet. If it is a star, the system is more properly referred to as an eclipsing binary. While such systems would seem to have great potential, it is extremely difficult to disentangle the limb-darkened profile from other parameters describing the fit to an eclipsing-binary light curve (Popper 1984, 1985). The first extrasolar transiting planet to be discovered is HD 209458b (Charbonneau et al. 2000). Because the planet is much smaller and darker than the star, its transits can be used to trace the stellar light profile in great detail (Brown et al. 2001). Moreover, it is generally expected that ongoing and future transit surveys will turn up several more such systems.

There is one other method that can distinguish between light coming from different parts of a star. If a star passes through a microlensing pattern, different parts of the star are magnified by different amounts. In practice, differential magnification is significant only when the star passes through a caustic, which is a region of formally infinite magnification for a point source. Up to now, the best measurement of microlens limb darkening has been from MACHO 97-BLG-28 (Albrow et al. 1999a). This is because the event included a cusp crossing and thus the magnification pattern

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was sharper, thereby giving better resolution across the star. In addition, the data for this event are very good. Albrow et al. (1999a) were able to measure two limb-darkening parameters each in V and I for the K giant source. They demonstrated that the resulting surface profiles are in reasonable agreement with the predictions of atmospheric models for stars of the same spectral type. However, they were not able to challenge these models.

Afonso et al. (2000) obtained a linear limb-darkening coefficient in each of four bands for an A star in the Small Magellanic Cloud (MACHO 98-SMC-1). They confirmed the expected trend of increased limb darkening toward the blue, but the measurements are not precise enough to challenge models. The primary difficulty is that the source star is extremely faint, $I \sim 22$, so that even when it is highly magnified, the signal-to-noise ratio (S/N) is modest.

Albrow et al. (2000) obtained linear limb-darkening coefficients for a red clump giant (MACHO 97-BLG-41). Even though the event itself was quite favorable, with three caustic crossings and a cusp crossing, bad weather and bad luck combined to limit the sensitivity of the data to limb darkening.

The limb-darkening analysis of OGLE-1999-BUL-23 by Albrow et al. (2001) was a major breakthrough in this subject. They developed a method to simultaneously compare limb-darkening measurements in two bands (V and I) with the predictions of a whole suite of atmospheric models. The analysis demonstrated a conflict only at the 2 σ level, so no significant conclusions could be drawn. However, if the density of measurements had been higher or the errors smaller, this technique would have been able to give observational input into atmospheric modeling of the limb darkening of a moderately evolved star for the first time.

The binary-lens microlensing event EROS BLG-2000-5 provides the best constraints on limb darkening by any microlensing event. This event has a caustic crossing that is 4 days long. This extraordinarily long timescale and the generally excellent weather for all 4 days at all five observatories combine to yield an extremely high density of coverage of the source crossing in units of its own radius. The first caustic crossing is well measured (fortuitously, since its onset cannot be predicted beforehand), and the event contains a cusp approach in addition to the two caustics. Hence, this event is better constrained than any other microlensing event (An et al. 2002). With the physical parameters of the event well constrained, higher order terms in the microlensing parameterization such as limb darkening can be precisely determined. In fact, An et al. (2002) derive a two-parameter limb-darkening model as part of their general solution, but only for I band, to which their analysis is restricted.

We are not the first, then, to provide high-precision measurements of limb darkening in stars, let alone giants. Both Albrow et al. (1999a) and Wittkowski et al. (2001) have done so using microlensing and interferometry, respectively. In addition, both showed that the atmospheric models give good predictions as to the limb darkening of their respective stars. However, neither of these studies compared the models with the data in a parameterized space that was capable of challenging the models. For example, Wittkowski et al. (2001) shows that the limb-darkening models for his stars are preferred over models of stars of different spectral type, but he does not perform the analysis in a space for which the models and the data are independent of each other. Conversely, Albrow et al. (2001) contrast the models and the data in a space for which both quantities are independent of each other, but the data are not of sufficient precision to confront the models. For the first time we present an analysis that is capable of challenging the atmospheric models with data good enough to do the job.

We extend the I-band analysis of An et al. (2002) to encompass four additional filters (V, V_E, I_E, and H). In addition, we have spectroscopic data for this star (taken when it was highly magnified) that give us independent information about its temperature, metallicity, and surface gravity. This combination of information allows us to confront model atmospheres of what we determine to be a K3 III star in all five bands. We test the Kurucz ATLAS models (Claret 2000) in the Johnson-Cousins V, I, and H bands, and the Hauschildt Next^{2}Gen models in the same Johnson-Cousins bands plus two nonstandard bands, V_E and I_E. (The Next^{2}Gen models are the current versions of the NextGen models described in Hauschildt et al. 1999a, 1999b.)

2. DATA

In our analysis of EROS BLG-2000-5 we make use of 11 data sets in five filters. The PLANET collaboration contributes nine data sets in three standard filters: three sets in V, four in I, and two in H. A description of the I-band data can be found in An et al. (2002). The V-band data are very similar in quality to the I-band, the main difference being that they contain about half the number of points. The H-band data were taken at SAAO and YALO by the instruments DANDICAM and ANDICAM, respectively. The instruments and procedures are identical in these two cases, and each contains a Tektronix 2048 × 2048 CCD and a Rockwell 1024 × 1024 HgCdTe IR array. The light path contains a dichroic that allows optical and near-IR images to be obtained simultaneously at the same position on the sky. The H-band images are constructed by averaging five contiguous dithered frames of 60 s each. The dithered images are flat-field–corrected and then used to create a median sky image, which is subtracted from the individual frames before they are shifted and co-added. The last two data sets are from the EROS collaboration and are those described in Afonso et al. (2003). The data are taken in V-like and I-like bands (V_E and I_E), which are more fully described in Afonso et al. (2001). The data reduction for the SAAO (V, I, and H), and YALO (V, I, and H) is done using DoPHOT (Schechter, Mateo, & Saha 1993). The EROS data are reduced using PEIDA (Ansari 1996) and are more fully described in Afonso et al. (2003). Difference imaging primarily using ISIS (Alard 2000) improves the Canopus (V and I) and Perth (I only) photometry, and so this method is carried out for these three data sets. In the same manner as An et al. (2002), each data set is cleaned of bad points by removing those with such high χ^2 that they are inconsistent with any model. Note that the number of points in the PLANET I-band data sets may be individually different from that given in An et al. (2002), as these cuts were done independently. However, since the total difference is only 10 points out of 1287, the impact on our conclusions is negligible. Finally, each data set has its errors rescaled so that the reduced χ^2 is unity for the best-fit model. The attributes of the data sets are given in Table 1.

TABLE 1
DATA SETS

Band	Observatory	Number of Points	σ Scaling
V	SAAO	177	1.46
	Canopus	154	1.96
	YALO	233	1.23
V_E	EROS	830	1.59
I_E	EROS	904	1.66
I	SAAO	404	1.75
	Canopus	311	2.73
	YALO	424	1.59
	Perth	148	2.77
H	SAAO	549	2.47
	YALO	659	1.94

3. MODEL

We continue the model formalism of An et al. (2002), which contains 11 geometric parameters. Seven of these are static binary lens parameters: the lens separation in units of the Einstein radius d_{t_c} (hereafter simply d), the binary lens mass ratio q, the angle between the direction of motion of the source and the binary lens axis α', the distance between the cusp and the source at closest approach u_c, the time taken to travel an Einstein radius $t'_{\rm E}$, the time of closest approach to the cusp t_c, and the ratio of source radius to Einstein radius ρ_*. Two are rotational parameters, $\dot{d}$ and ω, and two are vector components of microlens parallax, $\pi_{\rm E,\parallel}$ and $\pi_{\rm E,\perp}$. The derivation of this parameterization and its relation to the standard formalism is given in An et al. (2002). Our geometric solution and that of An et al. (2002) are given in Table 2.

In addition, each observatory and band has its own five photometric parameters: the unmagnified source flux f_s, the blend flux f_b, a linear seeing correction η_s, a linear limb-darkening parameter Γ, and a square root limb-darkening parameter Λ. These photometric parameters are returned from a linear fit to the magnification curve determined by the 11 geometric parameters. For each band (V, I, and H) that is observed from several observatories, all observatories are constrained to give the same values of Γ and Λ.

TABLE 2
MODEL PARAMETERS FOR EROS BLG-2000-5

Parameter	Joint Solution	An et al. (2002)
d	1.940	1.928 ± 0.004
q	0.75	0.7485 ± 0.0066
α'	73°.851151	74°.18 ± 0°.41
u_c	-5.096×10^{-3}	$(-5.12 \pm 0.03) \times 10^{-3}$
$t'_{\rm E}$ (days)	100.371	99.8 ± 1.5
t_c[a]	1736.941939	1736.944 ± 0.005
ρ_*	4.767×10^{-3}	$(4.80 \pm 0.04) \times 10^{-3}$
$\pi_{\rm E,\parallel}$	−0.193073	-0.165 ± 0.042
$\pi_{\rm E,\perp}$	0.195951	0.222 ± 0.031
$\dot{d}$ (yr^{-1})	0.280	0.203 ± 0.016
ω (yr^{-1})	0.0157	0.006 ± 0.076

[a] Heliocentric Julian Date − 2,450,000.

The form of the limb-darkening law we use is

$$S_\lambda(\vartheta) = \bar{S}_\lambda\left[(1-\Gamma_\lambda-\Lambda_\lambda) + \frac{3\Gamma_\lambda}{2}\cos\vartheta + \frac{5\Lambda_\lambda}{4}\sqrt{\cos\vartheta}\right], \quad (1)$$

which conserves flux independent of Γ and Λ, with $\bar{S}_\lambda$ being the mean surface brightness of the source and ϑ the angle between the normal to the stellar surface and the line of sight. This law is a different form of the more widely used one,

$$S_\lambda(\vartheta) = S_\lambda(0)\left[1 - c_\lambda(1-\cos\vartheta) - d_\lambda(1-\sqrt{\cos\vartheta})\right]. \quad (2)$$

It should be noted, however, that equation (2) is normalized to the flux at the center, and thus the total flux is a function of $S_\lambda(0)$, c_λ, and d_λ.

The transformation of the coefficients in equation (1) to the usual coefficients used in equation (2) is given by

$$c_\lambda = \frac{6\Gamma_\lambda}{4+2\Gamma_\lambda+\Lambda_\lambda}, \quad d_\lambda = \frac{5\Lambda_\lambda}{4+2\Gamma_\lambda+\Lambda_\lambda}, \quad (3)$$

while the inverse transformation is

$$\Gamma_\lambda = 10c_\lambda/(15-5c_\lambda-3d_\lambda)$$

and

$$\Lambda_\lambda = 12d_\lambda/(15-5c_\lambda-3d_\lambda).$$

The limb-darkening parameters are primarily determined by the behavior of the light curve between the time the source edge enters the caustic and the time the source center enters the caustic (and the inverse of this process as the source leaves the caustic).

We then take this model and expand it to include all five bands, constraining all observations in the same band to give the same limb-darkening parameters. However, since there are no seeing data for EROS, these two bands do not have seeing corrections. This gives our model a total of 11 geometric plus (5 photometric × 11 data sets − 2 EROS seeing coefficients) = 64 fit parameters, which are then subject to $(2V+3I+1H)\times 2$ limb-darkening parameters = 12 constraints.

4. ANALYSIS

4.1. χ^2 *Minimization*

The division of the model parameters into two categories, geometric and photometric, takes on additional significance when we search for a minimum in the χ^2 surface of the microlens model. A best fit can always be algebraically made to a linear equation. Unfortunately, the microlens model contains nonlinear parameters, for which a separate method must be applied. We therefore perform a grid search over the nonlinear (geometric) parameters, solving for the linear (photometric) parameters at each fixed geometry. This hybrid technique has the advantage of varying over all the parameters simultaneously, while still retaining the direct minimization of the linear parameters.

We employ a simple grid-search algorithm and not a more efficient technique such as simplex to minimize over the 11 geometric parameters because the (apparent) χ^2 surface is rough, with many false minima. This problem forces us to restrict our automated grid search to nine of the geometric parameters at each fixed (d, q). At each (d, q) we initialize the other nine geometric parameters, as well as the step size in those parameters. We then vary 0, 1, and 2 parameters at a time, calculating χ^2 at each of these 163 geometries. The "central" geometry is then set to be that with the lowest χ^2, and the variation begins again. If none of the neighboring geometries have a lower χ^2, the step sizes for all parameters are cut in half, and the grid search proceeds again. The minimization is declared complete after a user-defined number of cuts in the step sizes. This is done to avoid descent into numerical noise. We then reinitialize the routine at another (d, q), and in this manner step through the (d, q) grid "by hand."

Even so, we find that we can locate the true minimum only to within $\sim$0.02 in d and q, despite the fact that the true errors in these parameters (as determined from the curvature of the χ^2 surface measured over larger scales) are less than 0.01; that is, the apparent χ^2 varies by $\sim$10 for the same (d, q) when we initialize our search using different values of the other nine parameters. We believe that this roughness is most likely due to numerical noise rather than roughness in the "true" χ^2 surface. However, regardless of the exact cause of the roughness of the surface, its impact via increased uncertainty in (d, q) on the errors in the limb-darkening parameters must be assessed. This will be done in § 4.2.

We start the grid search at the minimum found by An et al. (2002). This is reasonable as An et al. (2002) find limb darkening in the I band with a subset of our data. To save computation cycles, we first do a grid search using only I-, I_E-, and H-band data. After the new minimum has been approximately located, the V- and V_E-band data are finally included. The limb darkening of the best-fit microlens model is shown in Figure 1.

4.2. *Errors*

Contributions to the error in the limb-darkening parameters can be broken down into three sources: the photometric (which include limb-darkening) parameters, the geometric parameters minimized over in our automated routine, and d and q. The covariance matrix from the photometric parameters is easily obtained, as it is a by-product of the linear fit that solves for the photometric parameters. We then apply the hybrid statistical error analysis as given in Appendix D of An et al. (2002) to determine the combined covariance matrix for the nine geometric plus 55 photometric parameters. While this approach does yield an invertible covariance matrix, there are reasons not to trust this method in this particular instance. We have stated above in § 4.1 that the apparent χ^2 surface is rough, with numerical noise a possible culprit. An effect of numerical noise on the ideal χ^2 parabola is to artificially raise the χ^2 at any particular point in parameter space. This is illustrated in Figure 2. A good approximation to the true (numerical noise–free) parabola can be found by fitting to the outside envelope as noise will not decrease χ^2. We fit with this method the error induced by the nine geometric parameters that we minimize over. As stated above in § 4.1, we have 163 geometries at each step in the grid-search algorithm, each of which has its own limb-darkening parameters and χ^2. We use this as our input data set, fitting for each band separately. In all cases, we find that the Γ-Λ error ellipse induced by the nine geometric parameters is small compared with that induced by the photometric parameters. This implies that our somewhat ad hoc procedure for determining the geometry-induced errors does not significantly affect our overall error estimate. The two sets of error ellipses are well aligned, differing in orientation by only a few degrees. We add the resulting covariance matrices to obtain the geometric plus photometric errors.

Up to this point, we have not yet taken into account the error induced by d and q. The roughness of the χ^2 surface is also a factor in this analysis. Unfortunately, while it is theoretically possible to use the same method that we use on the other geometric parameters, it would take several orders of magnitude more computational resources than we currently have to properly populate the geometric figure analogous to Figure 2. We instead investigate whether and to what extent the additional error in our limb-darkening parameters induced by d and q will affect our conclusions.

To this end, we first define

$$(\Delta\chi^2)_{\rm LD} = \sum_{i,j} \delta a_i b_{ij} \delta a_j \ , \qquad (4)$$

where δa_i is a vector whose components are the differences between the limb-darkening parameters of our best-fit model and a comparison model. Here $b_{ij} \equiv (c_{ij})^{-1}$ and c_{ij} is the covariance matrix of the limb-darkening parameters evaluated at the best-fit model. We define equation (4) as $\Delta\chi^2$ because it is the distance, expressed in χ^2 and normalized by the error ellipsoid, between models that both attempt to describe the data. We then compare our best-fit microlens model with other microlens models over the roughly (0.02×0.02) region of the (d, q) space over which χ^2 cannot be properly minimized on account of the roughness in the χ^2 surface described in § 4.1. We find that the limb-darkening parameters vary by less than 1 σ. By comparison, as we show in § 4.4 and § 4.5, the limb-darkening parameters of our best-fit model differ from those predicted by the stellar models by more than 10 σ. We conclude that the additional errors resulting from both the uncertainty in d and q and the underlying numerical noise do not affect our overall conclusions. We recognize that this additional error exists, but given that we have no way to quantify it properly, we simply report the error induced by the photometric and other nine geometric parameters in Table 3.

4.3. *Independent Analysis of Source Star*

When we compare our limb-darkening results with the atmospheric models in §§ 4.4 and 4.5, we wish to restrict attention to models that are relevant to the source star. We therefore begin by summarizing the results of an analysis of the source's physical properties as given by An et al. (2002). Assuming no differential reddening across the field, the dereddened color and magnitude of the source can be found by measuring the source offset from the red clump identified in a color-magnitude diagram of the field: $(V-I)_0 = 1.390 \pm 0.010$ and $I_0 = 14.70 \pm 0.03$. From its color and the fact that it is a giant (see below), the source is a K3 III star with a corresponding $T_{\rm eff} = 4200$ K. The color and magnitude imply a source angular radius $\theta_* = (6.62 \pm 0.58)$ μas. The source-lens relative proper motion and source radial velocity imply that the source most probably lies in the bulge, i.e., at $d_s \sim 8$ kpc, which implies a physical radius $r_* = d_s\theta_* = 11.4 \pm 1.0$ $R_\odot$. From kinematic information, An et al. (2002) find that

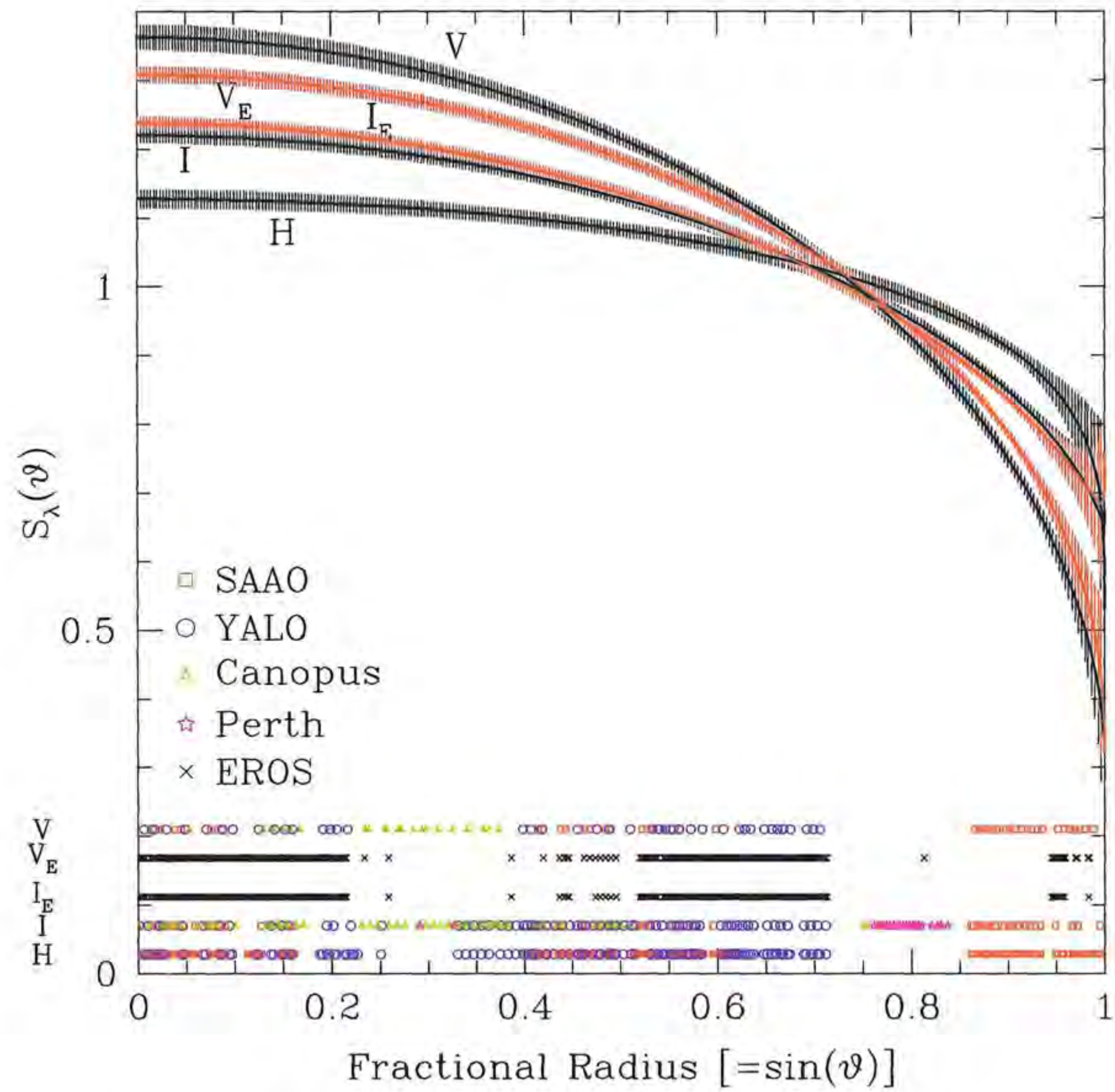

FIG. 1.—Derived brightness profiles for the source star of EROS BLG-2000-5 in all five bands, V, V_E, I_E, I, and H. The shaded regions around the curves are the 3 σ error envelopes. Also shown are points indicating when data were taken at each observatory, expressed in distance from the caustic to the center of the source in units of the source radius. At this point, the magnification pattern over the source profile is discontinuous, which gives us precise information about the profile at that point. For example, since the I band has almost continuous coverage across the entire source star, we can be confident that the brightness profile well represents reality. The V and H bands have a gap in coverage around $\sin \vartheta = 0.8$, and thus we can be less confident of the profile there. The EROS data, produced by a single observatory, have large gaps but are still able to make the two-parameter fit on account of their very dense coverage when the observatory was active.

TABLE 3

LIMB-DARKENING PARAMETERS, ERRORS, AND CORRELATION COEFFICIENTS

Parameter	V Band	V_E Band	I_E Band	I Band	H Band
Γ	0.7856 ± 0.1058	0.5500 ± 0.0979	0.7280 ± 0.0884	0.5622 ± 0.0861	0.0252 ± 0.1103
Λ	-0.1192 ± 0.1981	0.1342 ± 0.1919	-0.5029 ± 0.1772	-0.2434 ± 0.1680	0.4598 ± 0.2141
$\tilde{c}_{ij}$	-0.9950	-0.9969	-0.9978	-0.9964	-0.9970
φ[a]	$-61^\circ.96$	$-63^\circ.02$	$-63^\circ.52$	$-62^\circ.92$	$-62^\circ.79$
$\Gamma_I \cos\varphi + \Lambda_I \sin\varphi$[b]	0.4745 ± 0.2243	0.1299 ± 0.2153	0.7747 ± 0.1979	0.4726 ± 0.1886	-0.3974 ± 0.2408
$\Lambda_I \cos\varphi - \Gamma_I \sin\varphi$[c]	0.6374 ± 0.0093	0.5510 ± 0.0069	0.4275 ± 0.0053	0.3898 ± 0.0065	0.2326 ± 0.0075

[a] Location of major axis of error ellipse.

[b] Rotational transformation that maximizes the variance.

[c] Rotational transformation that minimizes the variance.

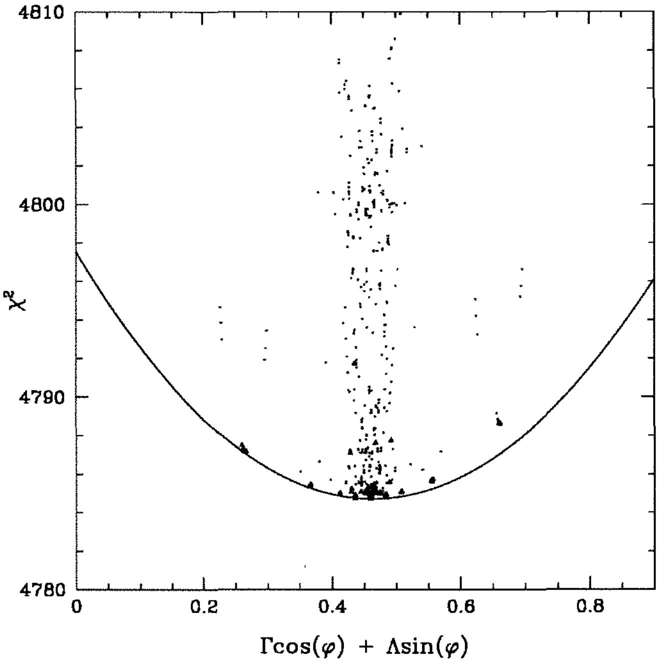

FIG. 2.—*I*-band χ^2 surface plotted as (Γ, Λ, χ^2) and viewed along the minor axis of the error ellipse. Each point represents a slightly varied geometry and its associated χ^2 and limb-darkening parameters. The filled triangles are those points we use to create the covariance matrix. The parabola is the cut through the geometric error paraboloid for this particular viewing angle. Numerical noise will lift points in χ^2 at a particular (Γ, Λ) and is responsible for the larger χ^2 among those points that we do not use. Note that as the points are seen in projection and the paraboloid in section, the apparent elevation of the points is a combination of noise and projection effects.

while it is possible that the source lies in the far disk (and so is physically bigger), it essentially cannot lie in the near disk. Since the source is either in the bulge or in the far disk ~500 pc above the plane, it must be a fairly old giant and therefore have a mass $M \sim 1\ M_{\odot}$. The mass and radius combine to give $\log g \sim 2.3$. If it lies in the far disk at 12 kpc then $\log g$ can be as much as 0.3 dex smaller.

S. I. Ramírez, S. Castro, & R. M. Rich (2003, in preparation) have analyzed High-Resolution Echelle Spectrograph Keck spectra taken by Castro et al. (2001), on the last two nights of the caustic crossing, HJD 2,451,731.953 and HJD 2,451,732.950, when the source center was approximately 0.25 and 0.75 source radii outside the caustic, respectively. First, they estimate the microturbulence for a set of $T_{\rm eff}$ and $\log g$ models, requiring that the Fe abundance computed from the Fe I lines be independent of the strength of the lines. Then for each gravity they determine a $T_{\rm eff}$ requiring that the Fe abundance computed from the Fe I lines be independent of the excitation potential of the lines. Then, they compute the Fe abundance from Fe II at those $T_{\rm eff}$ and microturbulence, varying $\log g$, and finally they determine $\log g$ by requiring no difference in the Fe abundance between the Fe I and Fe II lines.

They estimate $T_{\rm eff} = 4250$ K, $\log g = 1.75$, $[{\rm Fe/H}] = +0.29 \pm 0.04$, and $v_T = 1.19$ on the first night and $T_{\rm eff} = 4450$ K, $\log g = 2.25$, $[{\rm Fe/H}] = +0.22 \pm 0.07$, and $v_T = 1.77$ on the second. The gravity is too loosely constrained in this analysis to be of any use, but fortunately we have the photometric method applied to the An et al. (2002) results given above, which is both simpler and more robust. Because the source is differentially magnified while the models are not, this spectroscopic approach is not fully self-consistent. Nevertheless, we expect the error induced to be modest, particularly on the first night when the limb of the star is not particularly emphasized in the integrated source light. Since, in addition, both the observing conditions and S/N were substantially better the first night, we adopt $T_{\rm eff} = 4250$ K and $[{\rm Fe/H}] = +0.3$ as the spectroscopic determinations. The former is in excellent agreement with the photometric determinations described above. We designate the model for which $T_{\rm eff} = 4200$ K, [Fe/H] + 0.3, and $\log g = 2.3$ as the most physical model (MPM).

If we are to use these estimates to define a viable region of model-atmosphere parameter space, we need error estimates as well. High-resolution spectroscopic temperature estimates are routinely good to 100 K. Similarly, our photometric temperature estimate can be off by a 100 K, depending on differential reddening. As summarized above, the source gravity is strongly constrained by the angular size measurement and distance estimates. One could possibly push the source into the near part of the bulge, or into the far disk, but that is all. There is also some error associated with the mass estimation, but because of age constraints the mass cannot be too far from $\sim 1\ M_{\odot}$. We budget a 20% mass error, corresponding to an age range of 4–16 Gyr, which should encompass the great majority of bulge stars. Considering all such errors gives us the range $\log g = 2.3^{+0.3}_{-0.4}$. The metallicity is the least well constrained. This is only a minor problem, for, as we show in §§ 4.4 and 4.5, metallicity has only a minor effect on the model atmosphere limb-darkening curves. We set our lower metallicity limit at solar. Physically reasonable models (PRMs) would then have $T_{\rm eff} = 4100$–4300 K, $\log g = 1.9$–2.6, and $[{\rm Fe/H}] = 0.0$ to $+0.3$.

4.4. *Comparison with ATLAS Models*

Claret (2000) fits five different limb-darkening laws to a suite of ATLAS model atmospheres supplied to him by R. Kurucz in 2000. Claret (2000) then reports the parameters for each of these limb-darkening laws. We compare our results with the linear plus square root law, rather than the favored four-parameter fit since we also use a linear plus square root law in our fitting, and thus the coefficients are comparable. Little is lost by this substitution, as the four-parameter and two-parameter fits differ by much less than the difference between the microlensing-based and atmospheric model profiles. We use equation (4) to create our measure of goodness of fit, but because we are now comparing theoretical atmospheric models with what we consider a parameterization of reality, we term the result "χ^2" rather than "$\Delta\chi^2$." Equation (4) implicitly assumes that the χ^2 surface is parabolic, which, since the microlensing fit is nonlinear, is not strictly the case. However, as shown in § 4.2, the covariance matrix is dominated by the linear part of the fit. Hence, the χ^2 surface is nearly parabolic. As before, δa_i is a difference in the limb-darkening parameters, this time between an atmospheric model and our microlensing result, and b_{ij} is the inverse of c_{ij}, the covariance matrix for the microlensing limb-darkening parameters. We convert the Claret (2000) c_λ and d_λ to Γ_λ and Λ_λ by using the inverse of equation (3) to make the comparison. We restrict the comparison to the standard (Johnson-Cousins) bands *V*, *I*, and *H*, because Claret (2000) reports limb-darkening parameters only for these.

Following the procedure pioneered by Albrow et al. (2001), we begin by simultaneously comparing the microlensing limb-darkening parameters from all three filters with the atmospheric model parameters, taking full account of the covariances among these six parameters. We restrict our investigation to those models with turbulent velocity $v_T = 2$ only. Models given by Claret (2000) with other v_T do not span the full parameter space required by our investigation, nor do we have independent information that would distinguish among different v_T as we do for $T_{\rm eff}$, [Fe/H], and $\log g$. Special attention is paid to two regions of the χ^2 surface: the neighborhood of the MPM to check for consistency between the atmospheric models and the microlens data, and features around $\chi^2_{\rm min}$ (which may not be near the MPM) to try to guide modelers in understanding the results of their simulations. The ATLAS parameter grid does not contain the MPM, but the closest is $T_{\rm eff} = 4250$ K, $\log g = 2.5$, and [M/H] = +0.3. We refer to this as the MPM while within § 4.4. In addition, the ATLAS models given in Claret (2000) have a larger grid spacing than the region covered by the PRMs, so we investigate $T_{\rm eff} = 4000$–4500 K, $\log g = 2.0$ and 2.5, and [M/H] from 0.0 to +0.3. We define consistency as having a $\chi^2 \lesssim 4$. We find that χ^2 at the MPM is 94. In fact, all the PRMs are high, with the lowest χ^2 among them at 38. This in itself is a major concern. That no model atmosphere agrees with our data, regardless of its parameters, is evident by the fact that $\chi^2_{\rm min} = 36$. This occurs at $T_{\rm eff} = 4500$ K, $\log g = 2.5$–3.5, and [M/H] = −0.1 and −0.2, which is incompatible with the other evidence we have about this star. We find that, in all the ATLAS models in the vicinity of the MPM, the differences in χ^2 between $\log g = 2.0$ and 2.5 are small compared with those induced by changes in the other two parameters. Across the PRMs, the magnitude of the change in χ^2 induced by $T_{\rm eff}$ is ~100, by metallicity, $\lesssim 10$, and by $\log g$, ~1. This is not true in the case of the V and I bands, for which the effect of gravity is approximately equal to that of the metallicity. Because of this lack of distinguishing power in the surface gravity, we focus our investigation on $\log g = 2.5$. Any model whose gravity is not listed should be assumed to have $\log g = 2.5$. To determine whether the large mismatch in limb-darkening parameters comes primarily from one specific band, we investigate the goodness of fit for each band separately.

4.4.1. *V Band*

We repeat our χ^2 minimization over the space of ATLAS models, considering only the V-band parameters Γ_V and Λ_V. The MPM has a χ^2 of 20. We then look for PRMs that might be consistent. All points with $T_{\rm eff} = 4500$ K have $\chi^2 < 4$ and are thus consistent. Because of the small spread in χ^2 within this sample (1.99–2.57), nothing can be said about favored values of [M/H] and $\log g$. It must be pointed out, however, that the grid spacing of the ATLAS models is larger than the true permitted temperature range. If we take this into account and note that at $T_{\rm eff} = 4250$ K, $\chi^2 > 14$, we must downgrade the V band to marginal inconsistency. The shape of the χ^2 surface near $\chi^2_{\rm min}$ returns a "valley" (part of which is shown in Fig. 3*b*) running along $T_{\rm eff} = 4500$ K. The V band has a greater dependence on $\log g$ than the combined all-band χ^2 surface.

4.4.2. *H Band*

We perform an analysis for H band in the same manner as in the previous section. The MPM has $\chi^2 = 2.7$. About half the PRMs are consistent as well. This avoids the caveat we applied in the previous section (§ 4.4.1). The H band also has a valley structure (Fig. 3*d*) in its χ^2 surface analogous to that in the V band, although there is some dependence on $T_{\rm eff}$ in the range that we investigate. This $T_{\rm eff}$ dependence is slight; the location of the "valley floor" shifts from $T_{\rm eff} = 3500$ K at [M/H] = −1.0 to $T_{\rm eff} = 4500$ K at [M/H] = +1.0. As in the all-band comparison, $\log g$ is essentially unimportant in the H band.

4.4.3. *I Band*

The I band MPM has $\chi^2 = 71$. None of its PRMs are consistent with the microlens limb darkening; the lowest χ^2 among them is 28. The $\chi^2_{\rm min}$ over the entire space of I-band models is still moderately high at 13. In general, it is the I band that is causing most of the discrepancy between models and data. The atmospheric models that have the lowest χ^2 form a track in parameter space that varies smoothly from solar-metallicity dwarfs at $T_{\rm eff} \sim 4750$ K to super–metal-poor supergiants at $T_{\rm eff} = 3500$ K. As discussed in § 4.4, in this band, as in the V band, the effect of surface gravity on χ^2 is of the same magnitude as the effect of metallicity. What is interesting is that the sense is opposite between these two bands. The I band slightly prefers a lower gravity, while the V band slightly prefers a higher gravity. When then summed together with the H band, the resultant all-band χ^2 surface does not favor one gravity over the other.

At this point, we can ask whether the bands are consistent with each other. In a relative sense, they are, as the PRMs with the lowest χ^2 are always those with $T_{\rm eff} = 4500$ K, no matter the band. We defer discussion as to the possible causes of the disagreement between the ATLAS atmospheric models and the microlens data until § 4.6, after we have investigated the Next^{2}Gen models.

4.5. *Comparison with Next^{2}Gen Models*

We analyze the limb darkening of Next^{2}Gen models between $T_{\rm eff} = 4000$ and 4600 K in 100 K increments, $\log g = 0.0$ and 3.5 in increments of 0.5, and [Fe/H] of −0.25, 0.0, and +0.3. The original format of these files is a spectrum between 3500 Å and 3 μm with a resolution of 0.5 Å at each of 99 points in $\cos \vartheta$.

Having the full spectra enables us to create limb-darkening profiles in nonstandard bands. We convolve the spectra with filter functions for all five filters in the microlens data (V, V_E, I_E, I, and H). We then use a simple linear fit to solve for the (Γ_λ, Λ_λ) for each filter.

The primary difficulty in this procedure is the definition of the edge of a star. The Next^{2}Gen atmospheres have a steep drop-off in intensity whose location in radius varies with surface gravity. Sample profiles are shown in Figure 4. This feature cannot be modeled by a linear plus square root limb-darkening law, and because it contributes almost nothing to the total flux, we decide to remove it. This is further warranted because even if we had the formalism in our microlensing code to fit this feature, we would not receive any useful information since our sampling is not dense enough at the specific part of the caustic exit during which the feature would be visible. We therefore excise this feature

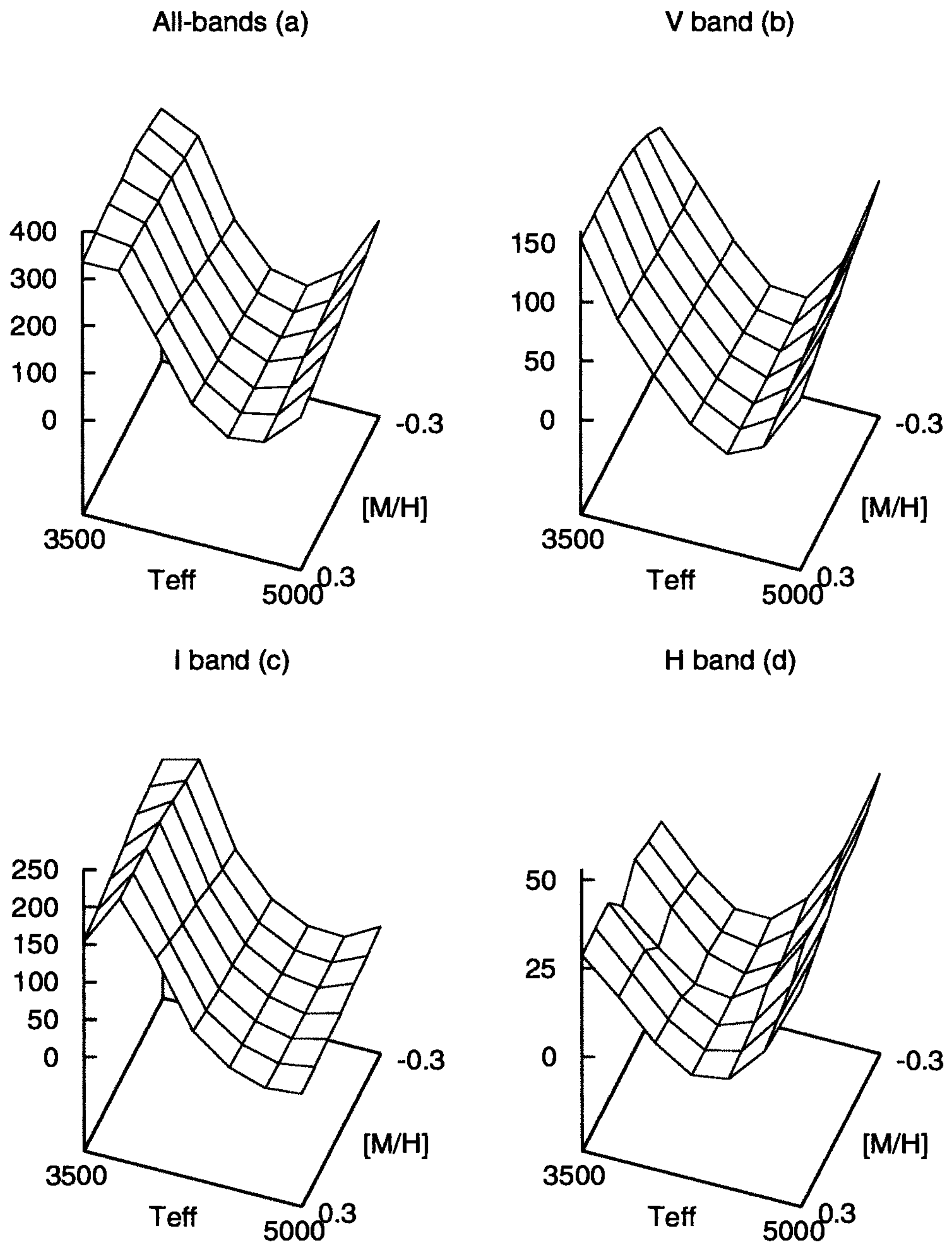

FIG. 3.—χ^2 surfaces of the microlens-ATLAS comparison at $\log g = 2.5$ for (*a*) the *V*, *I*, and *H* bands combined, (*b*) the *V* band, (*c*) the *I* band, and (*d*) the *H* band. The value of χ^2 is most dependent on $T_{\rm eff}$ and less dependent on [*M*/H]. The dependence on $\log g$ (not shown) is even weaker still. The surface of every band has a similar shape, a " valley " that runs through metallicity with almost constant $T_{\rm eff}$. These structures mostly overlap, although the *I* band's is shifted to slightly higher $T_{\rm eff}$.

by removing all points outside some chosen radius. We then rescale the value of the radius at each remaining point by the factor necessary to set the outermost point's radius equal to unity. The radius is chosen by finding the point at which the *H* band, which should suffer the least amount of limb darkening, drops steeply off. This is something of a judgment call, as individuals will pick slightly different truncation radii. This does not pose a problem, however, as tests indicate that the Next^{2}Gen profile is equally well fitted by a two-parameter limb-darkening law out to radii somewhat beyond this steep drop-off in flux (but not into the feature we are removing). In the profiles shown in Figure 4, this occurs around $r = 0.995$, indicating that our cut at $r = 0.993$ is acceptable. This procedure breaks down at low surface gravity. Supergiants have such a small density gradient that the surface of last scattering at different wavelengths varies greatly with radius. This would be a major concern for us if we did not have additional information telling us that this star was a luminosity class III giant. We use a separate truncation radius at each $\log g$ but not for each wavelength. Our adopted truncation radius varies between $r = 0.88$ at $\log g = 0.0$ to $r = 0.998$ at $\log g = 3.5$. Having a single truncation radius for all bands would induce problems at the low $\log g$ end, but such low surface gravities are already highly disfavored, as discussed in § 4.3.

In performing the fit, we sample the profile at the radii corresponding to the observations (see Fig. 1), giving equal weight to each point. We evaluate the profile at these radii

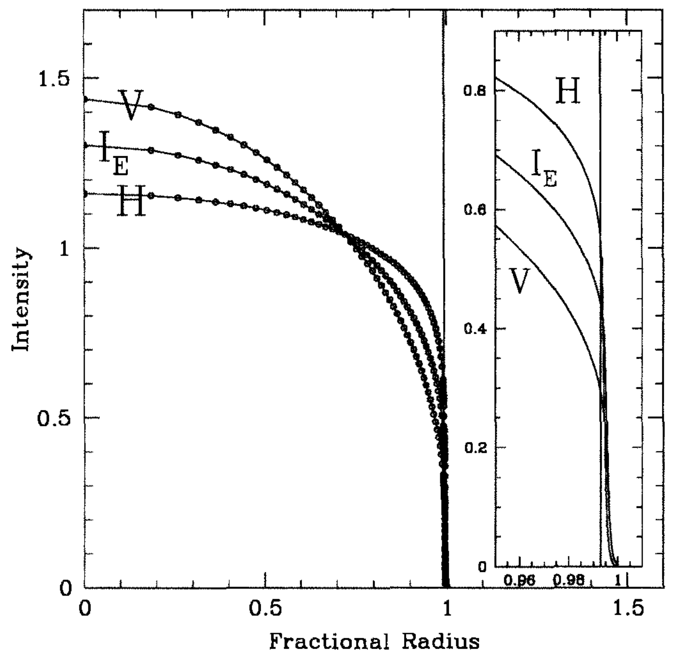

FIG. 4.—Sample limb-darkening profiles from the Next^{2}Gen model corresponding to the MPM ($T_{\rm eff} = 4200$ K, $\log g = 2.5$, [Fe/H] = +0.3). Shown are the V, I_E, and H bands. Each circle is a radial point in the Next^{2}Gen output. Also shown is the cut in radius that we impose at $r = 0.993$.

by interpolating among the points given by the Next^{2}Gen model. This produces a model profile that is most weighted in the regions that are most densely observed in the real data.

We then perform the same analysis as in § 4.4, creating a χ^2 surface between the microlens limb-darkening parameters and those of the Next^{2}Gen models. The only difference is that we now have 10 limb-darkening parameters instead of six because we are also matching V_E and I_E in addition to V, I, and H. As in the previous section, no grid points in parameter space for the Next^{2}Gen models coincide perfectly with the MPM, and the grid spacing does not perfectly coincide with the range of the parameters covered by the PRMs. In this section we consider $T_{\rm eff} = 4200$ K, $\log g = 2.5$, and [Fe/H] = +0.3 as the MPM, and we consider the range $T_{\rm eff} = 4100$ to 4300 K, $\log g = 2.0$ and 2.5, and [Fe/H] = 0.0 to +0.3 as that similar to our PRMs.

Turning now to the χ^2 analysis, the MPM is immediately ruled out: $\chi^2 = 877$. The PRMs are also ruled out, as the lowest χ^2 among them is 497. When we look over the entire parameter space, we find $\chi^2_{\rm min} = 133$ at $T_{\rm eff} = 4600$ K, $\log g = 2.5$, and [Fe/H] = −0.25. From Figure 5*a*, it appears likely that the true $\chi^2_{\rm min}$ is outside the explored parameter space, at least in $T_{\rm eff}$. There also appears to be a trend toward lower metallicity, so it is possible that the best-fit metallicity is also outside our explored parameter space. We discuss this further in § 4.6. In general, χ^2 increases with [Fe/H], and decreases with $T_{\rm eff}$. Surface gravities between $\log g = 1.0$ and 2.5 are preferred, with higher $T_{\rm eff}$ and lower metallicity selecting for a higher $\log g$.

4.5.1. *Johnson-Cousins V, I, and H Bands*

At the MPM, the V, I, and H bands have $\chi^2 = 81$, 136, and 21, respectively. Among the PRMs, all three bands prefer $T_{\rm eff} = 4300$ K and [Fe/H] = 0.0. A surface gravity of 2.5 is marginally preferred over 2.0 by the H band (the difference in χ^2 is ∼3), while the V and I bands do not significantly favor either gravity. The V, I, and H bands have χ^2 at this PRM of 32, 99, and 15. The global minima for these bands are the following: for the V band, $T_{\rm eff} = 4600$ K, $\log g = 3.5$, and [Fe/H] = −0.25, with $\chi^2_{\rm min} = 0.02$; for the I band, $T_{\rm eff} = 4600$ K, $\log g = 2.5$, and [Fe/H] = −0.25, with $\chi^2_{\rm min} = 37$; and for the H band, $T_{\rm eff} = 4600$ K, $\log g = 3.5$, and [Fe/H] = −0.25, with $\chi^2_{\rm min} = 1.14$. In sum, the all-band and I-band minima coincide, and the χ^2 values for bands V and H at the all-band minimum are just $\Delta\chi^2 \lesssim 0.5$ higher than at their own minima. That is, all three bands have the same minimum to within ∼1 σ.

Qualitatively, this shape of the χ^2 surface is replicated for each individual band, as can be seen from Figure 5. One minor difference is that the V-band surface has more curvature in $T_{\rm eff}$ while in the other bands, χ^2 is approximately a linear function of $T_{\rm eff}$. The other minor difference is that the H band favors high gravity independent of $T_{\rm eff}$, while the other bands tend to favor a lower surface gravity at lower $T_{\rm eff}$.

4.5.2. *EROS Bands V_E and I_E*

Each EROS band has a greater disagreement with every atmospheric model than any Johnson-Cousins band. The MPM has $\chi^2 = 387$ and 251 for V_E and I_E, respectively. The best PRM for both bands is $T_{\rm eff} = 4300$ K, $\log g = 2.0$, and [Fe/H] = 0.0, with $\chi^2 = 201$ and 146. The location of the $\chi^2_{\rm min}$ for the V_E and I_E bands is the same as for all bands, at $T_{\rm eff} = 4600$ K, $\log g = 2.5$, and [Fe/H] = −0.25, with $\chi^2 = 47$ and 47.

4.6. *Possible Systematic Effects*

Logically, there are only four possible sources for the discrepancy between the models and the data: (1) problems with the microlensing data, (2) problems with our analysis of the data, (3) problems with the atmosphere models, or (4) incorrect comparison of the models and the data. We now argue that (1), (2) and (4) are unlikely.

4.6.1. *Individual Observatories*

We test whether the data from an individual observatory drives the combined solution to an unsuitable answer. We rerun our fitting routine five times at the (d, q) of the combined-band solution, each time removing a different observatory's data, the exception being that we always keep both H-band data sets. The removal of the SAAO, Perth, or EROS data sets does not appreciably change the limb-darkening curves. In the V band, the removal of the Canopus data shifts the limb-darkening parameters by approximately 1 σ, and the removal of the YALO data shifts them by about 3 σ. The reverse is true in the I band; removing the Canopus data provokes a 3 σ change, while removing the YALO data induces only a 1 σ change. This test shows that any systematic effects in the data themselves are either present in data sets across all observatories or are so mild that they do not affect the combined solution at the level of the difference between microlensing measurements and the atmospheric models.

4.6.2. *PLANET versus EROS Data Sets*

We also analyze the solutions found by the PLANET data and EROS data separately. We expand the analysis to

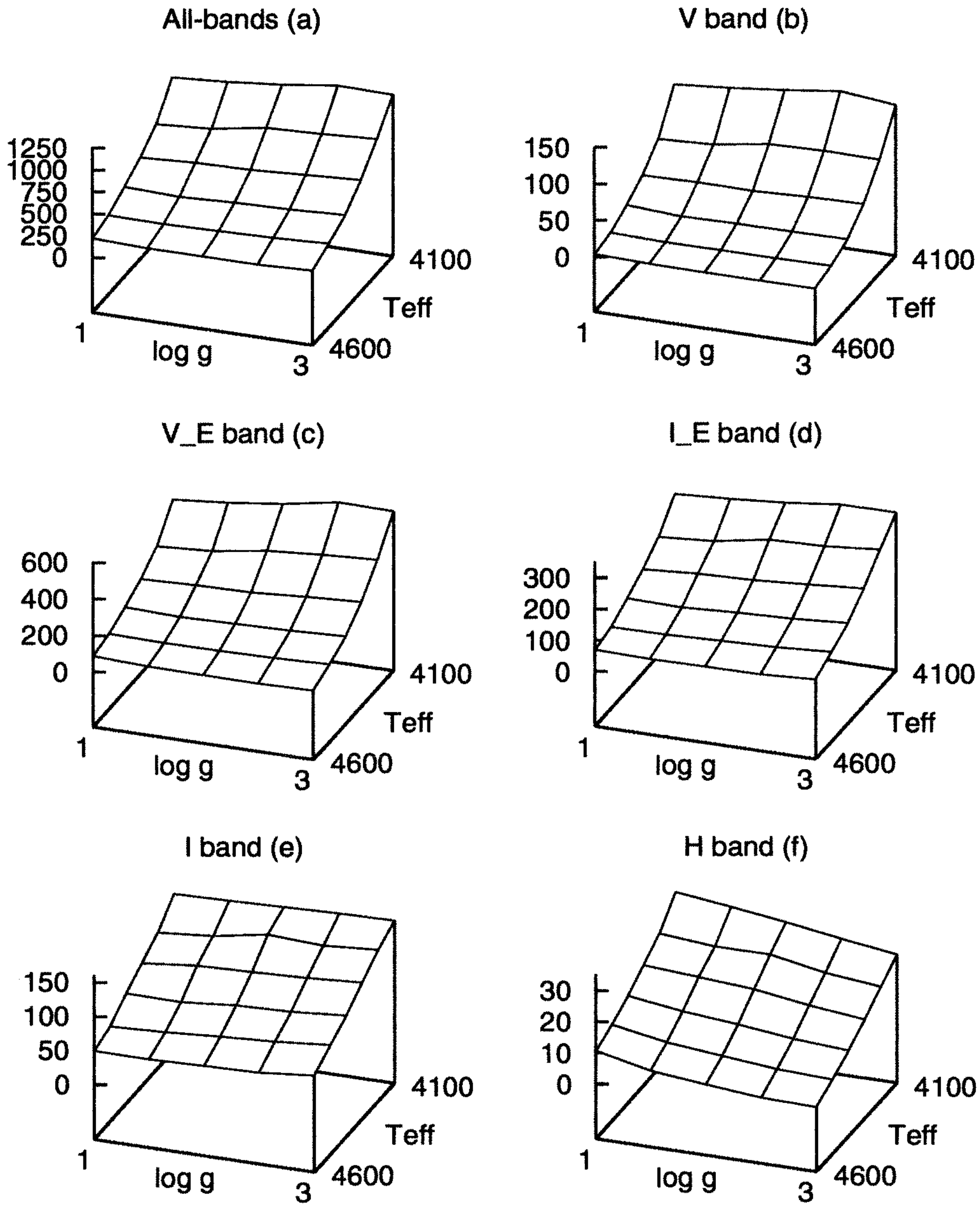

FIG. 5.—χ^2 surfaces of the microlens-Next^{2}Gen comparison at fixed [Fe/H] = +0.3 for (*a*) all bands, (*b*) the *V* band, (*c*) the V_E band, (*d*) the I_E band, (*e*) the *I* band, and (*f*) the *H* band. All the surfaces share the same general shape: monotonic dependence on $T_{\rm eff}$ and [Fe/H], with a favored value of log *g*. With the exception of very low log *g* (0.0–0.5), χ^2 varies most in $T_{\rm eff}$, with variations over log *g* and [Fe/H] (not shown) being much lower.

include searching for a solution over *d* and *q*. The PLANET-only solution is located at the same (*d*, *q*) as the combined solution. Moreover, as discussed in § 4.6.1, removing the EROS data does not appreciably change the limb-darkening profiles found from the remaining (i.e., PLANET) data. However, we find a very different result for the EROS-only solution. This is located at a (*d*, *q*) of (1.94, 0.77) that is (0.0, 0.02) away from the combined solution. The EROS-only solution has a χ^2 that is 75 lower than the χ^2 of the EROS bands at the combined solution. The derived stellar brightness profile is flat across the inner half of the star, then drops dramatically toward the limb. The ratio of intensities of the center to the limb are similar to that of the *V* band, but the shape of the EROS profiles are very different. The EROS-only profiles are a much better match to the Next^{2}Gen models than the EROS profiles derived at the all-band geometry. The χ^2 of the MPM drops from 387 and 251 to 174 and 69 for the V_E and I_E bands, respectively. However, the profiles from the EROS-only solution are still not actually consistent with any of the Next^2-Gen models, since $\chi^2_{\rm min} = 87$ and 32 in the two EROS bands.

Such a major inconsistency is a potentially serious problem. How can the previously described disagreement between atmospheric models and microlensing be trusted if the microlensing can produce such different fits? We argue that this problem can be resolved in the following manner: (1) we identify the feature that has the most diagnostic power with regards to the limb darkening, the caustic exit; (2) we show how the EROS data sets do not well determine this feature, although the combination of EROS and SAAO *H*-band data sets do; and (3) we investigate whether the large formal difference in χ^2 between the EROS-only and all-band geometries represents a failure of the model or of the data and what the consequences of that failure are.

We first examine the region from which we receive the most information about the limb darkening, near the caustic exit. This region is shown in Figure 6. An accurate estimate of the caustic-exit time is essential for determining the amount of darkening on the extreme limb. This can be illustrated by thinking about the data points just outside the true caustic exit. If the caustic exit were thought to occur later than it actually does, these points would be thought to be inside the caustic. Their faintness would therefore imply that the part of the star undergoing the strongest differential magnification (the limb) had very low surface brightness. On the other hand, if the caustic exit is recognized to occur before these points, their faintness is properly attributed to the fact that there are no additional images of the source, i.e., the source lies entirely outside the caustic.

This is exactly the issue with respect to the disagreement between the PLANET-only and EROS-only geometries. As Figure 6 shows, the EROS-only geometry places the caustic exit at a later time, which implies greater limb darkening. We therefore investigate how well the caustic-exit time is determined by the all-band data set and what the source of this discrepancy is.

First we note that the time of the caustic exit is essentially determined from the combination of the SAAO H-band data and the EROS data: the H-band data show an approximately linear fall toward the caustic exit, and this fall must break very close to the best-fit caustic exit if the magnification curve

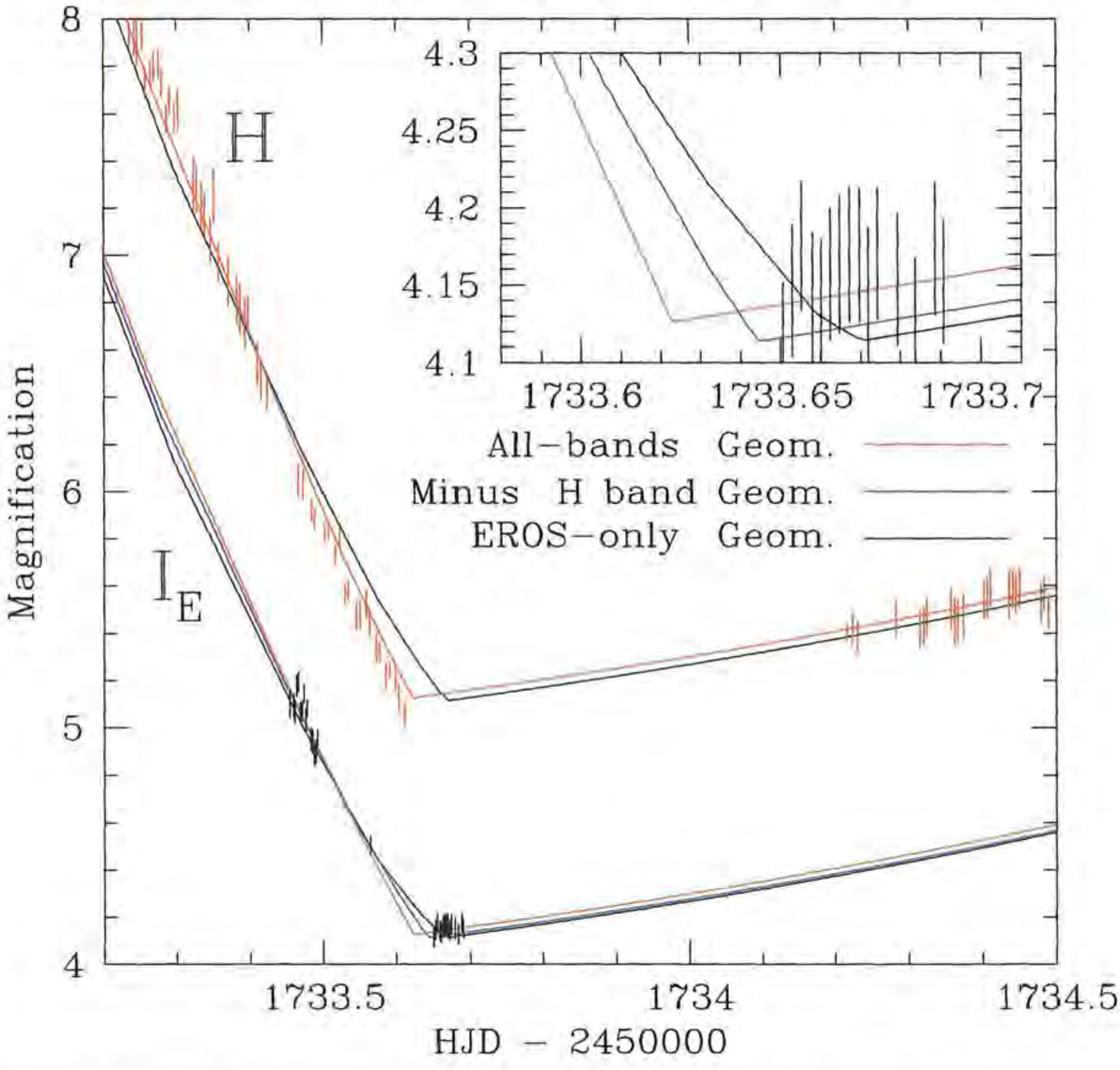

FIG. 6.—Magnification for EROS BLG-2000-5 in the H and I_E bands. The H band has been shifted by +1 in magnification to separate it from the I_E band. Also shown are the error bars for the SAAO H-band and EROS I_E-band data points. The magnification for each data point has been reconstructed using the observed flux, source flux, blend flux, and seeing correction, the last three of which are derived from the all-band solution. These three quantities are very stable and do not appreciably change between microlens models. The black lines show the predicted light curve derived from the geometry at the EROS-only solution, the blue line shows the predicted light curve from the geometry at the solution containing all data sets except the H band, and the red lines show the predicted light curve for the geometry at the all-band solution. *Inset*: Expanded view of the I_E caustic-exit region. Note that the I_E-band points could support either prediction, while the H-band points strongly favor the all-band solution.

is to remain continuous and still pass through the EROS I_E points. See Figure 6. Thus, the caustic-exit time can be specified virtually without reference to any model.

Even if the EROS points are eliminated from the fit, the best-fit light curve based on only PLANET data still passes through these EROS points and intersects the linearly falling SAAO H-band light curve at almost exactly the same caustic exit. Because the PLANET points that fix the post-exit magnification start up about 10 hr after the exit, when the magnification has already started to rise, this determination of the caustic exit is somewhat model dependent. However, the model dependence is quite weak. Hence, we have two independent and robust lines of evidence fixing the caustic-exit time, and for this reason we have high confidence in the result.

Nevertheless, it remains somewhat puzzling why the EROS-only solution prefers a later time. From Figure 6, it is clear that the EROS data near the caustic exit do not themselves strongly prefer one solution over the other. Hence, this discrepancy must be rooted in other parts of the light curve: either the EROS data have systematic errors elsewhere in the light curve, or the model does not exactly reproduce the true light curve.

To distinguish between these possibilities, we first exclude the H-band data and refit the light curve. The result is shown by the blue line in Figure 6, which is between the EROS-only solution and the PLANET-only solution. Clearly the pressure toward a late caustic exit is not coming from the EROS data alone. To verify this, we eliminate the H band, the remaining SAAO bands, and the EROS data. The resulting exit, which lies almost on top of the blue line of the minus-H-band geometry, also lies halfway between the PLANET-only and EROS-only values. Since the problem is not restricted to one data set, we conclude that the model must imperfectly predict the data elsewhere in the light curve. We have attempted to isolate this discrepancy by using various techniques but have not succeeded because the effect is extremely small and manifests itself only when data far from the caustic exit are used to predict the caustic-exit time. As with any such extrapolation, caustic-exit predictions in particular (Albrow et al. 1999b), small errors can be vastly magnified when predicting distant effects.

We must also determine how much the fit to the caustic region (and so the limb-darkening measurement) is being distorted on account of data far away. To do so, we decrease the error by a factor of 10 on the group of H-band points just before the caustic exit. This should increase the relative importance of this region to the overall fit and be able to tell us to what extent the light curve near the caustic exit is being influenced by data far away. The caustic exit shifts slightly to an earlier time, as we should expect given that data far from the caustic tends to shift it to later times. This shift, however, does not produce substantial changes in the limb-darkening curves, shifting them by 1 σ–1.5 σ on average. We conclude that the caustic exit is very well determined, and the discrepancies related to it do not significantly affect the limb-darkening determinations.

4.6.3. *Fitting Routine*

It is unlikely that our fitting routine is the source of the conflict. We fitted all the data simultaneously, so one would expect that any systematic effects would have to be present in all bands. The limb-darkening curves in these five bands are all internally consistent with each other. Without outside information, the microlensing routine found that the amount of limb darkening increases with decreasing wavelength, starting from a very flat profile in H band and progressing through I, I_E, and V_E to a relatively steep V-band profile (see Fig. 1). Even the relative amounts of limb darkening are roughly correct. The mean wavelength of the I_E band is 14% of the way between that of the I and V bands (Afonso et al. 2000), and indeed, the I_E-band limb-darkening profile is very similar to the I-band profile. The mean wavelength of the V_E band is 27% of the way between V and I (Afonso et al. 2000), and the V_E profile is more like the V-band profile than the I-band profile, and as expected the degree of similarity between the V_E and V profiles does not match that between the I_E and I.

It is also unlikely that statistical fluctuations could be the cause of the disagreement between the microlens data and the atmospheric models. We note that the disagreement for just the V, I, and H bands with both the ATLAS and Next^{2}Gen models are substantially greater than $\chi^2 = 100$. Even at $\chi^2 = 100$, the probability of random fluctuations being responsible is $\sim 10^{-19}$.

4.6.4. *Atmospheric Models*

Figure 7 compares the I-band limb darkening derived from microlensing with a suite of ATLAS atmospheric models all at the same $\log g = 2.5$ and $[\mathrm{M/H}] = +0.3$ but with different temperatures. A striking feature of this figure is that all the atmospheric models go through a single point, one that the microlensing model does not go through. This exact feature is also present in the Next^{2}Gen models shown in Figure 8. This common feature is not apparent when the limb-darkening curves are normalized in the usual (c_λ, d_λ) formalism. It appears only when limb-darkening curves are plotted to conserve total flux as in equation (1). Such a fixed point would be a generic feature of any single-parameter limb-darkening profile of the form

$$S(r) = K[1 + af(r)] , \qquad (5)$$

where $r = \sin(\vartheta)$ is the normalized angular radius, K is the normalizing factor such that the profile has unit flux, a is the limb-darkening coefficient, and $f(r)$ is an arbitrary function of r. This fixed point is located at $r_{\rm fix} = f^{-1}[2\int_0^1 f(r')r'\,dr']$. For example, for linear limb-darkening of the form $f(r) = 1 - (1 - r^2)^{1/2}$, $r_{\rm fix} = 5^{1/2}/3 \sim 0.745$.

However, such a fixed point is not required in a two-parameter limb-darkening law such as we use. Nonetheless, it still appears in the atmospheric models. What is more, the limb-darkening profile for the Sun (the only star in the sky with better measured limb darkening than EROS BLG-2000-5) also passes through this point that all the atmospheric models share; that is, the models all carry a common feature that is also present in the Sun but does not exist in the giant EROS BLG-2000-5.

Heyrovský (2000) was the first to find these fixed points, specifically for the standard linear limb-darkening law and for a single-parameter principal component analysis (PCA). Heyrovský (2000) notes that the solar data can be reproduced using just the first component of a PCA basis derived from cool-star models. He argues for a physical origin of this effect, namely, that both cool giants and the Sun share a

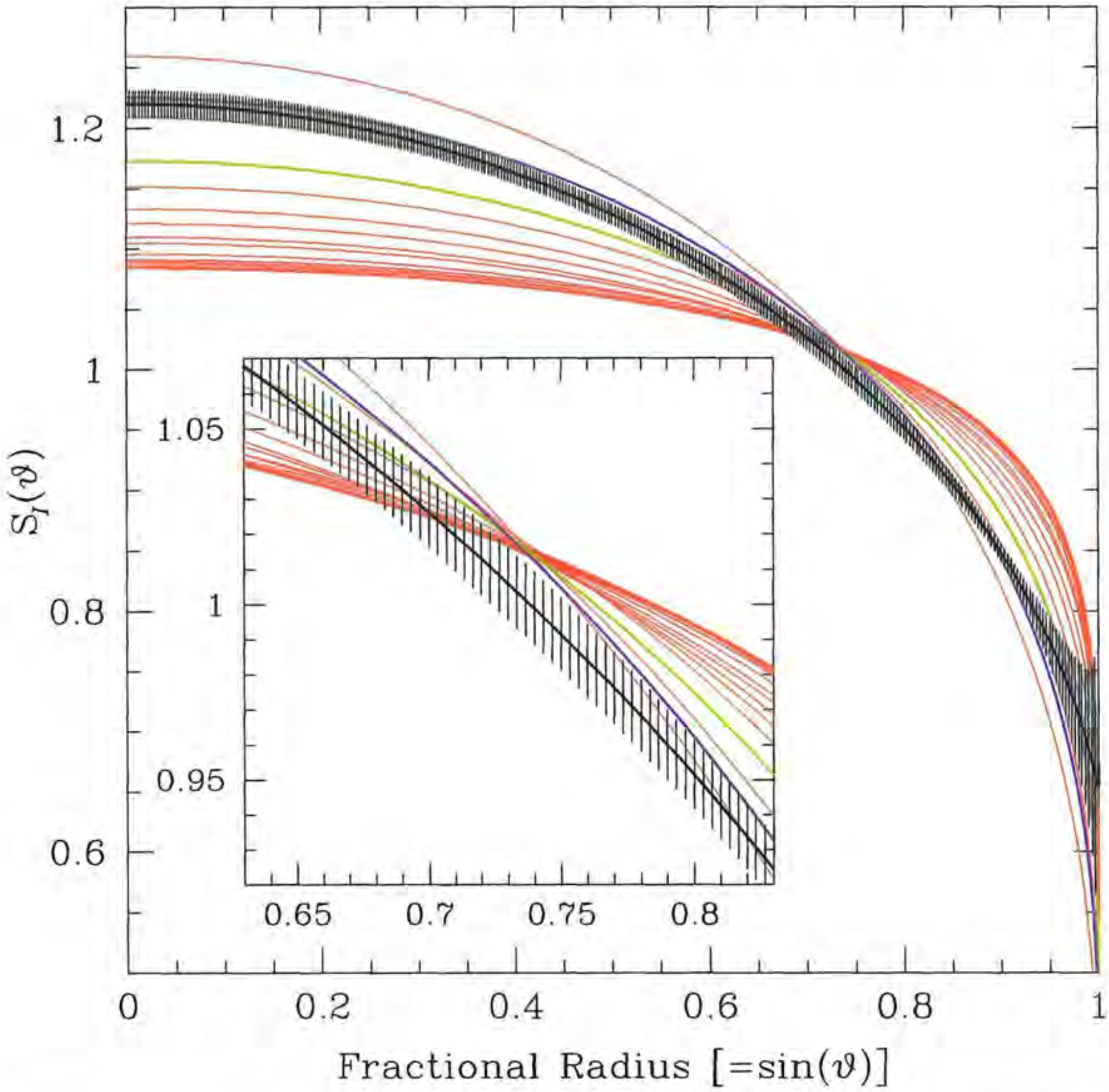

FIG. 7.—Brightness profile in the I band. The black line and shading are EROS BLG-2000-5 and its associated 3 σ error envelope. The red lines give ATLAS models (Claret 2000) at $\log g = 2.5$ and $[M/H] = +0.3$ for $T_{\rm eff}$ between 3000 and 18,000 K, in 1000 K increments with the lowest-temperature model the most highly limb darkened (i.e., the curve that is the brightest in the center and dimmest at the limb). The blue line corresponds to the best-fit ATLAS model at $T_{\rm eff} = 4500$ K, $\log g = 3.0$, and $[M/H] = -0.3$. Also shown is the I-band curve of the Sun in green. As can be seen, there is a point that all the model curves share with the Sun at approximately $(r, S_I) = (0.74, 1.02)$. This fixed point, which is not shared by the microlensing-determined profile, is not apparent in the (c_λ, d_λ) formalism.

primary opacity source: H^-. We conjecture that these models, which are capable of producing fits to the Sun, incorporate physics that is completely applicable only to the solar regime. This may relate to opacity or to some other physical mechanism. Whatever the source of the discrepancy, this deserves further study.

4.6.5. *ATLAS-Next²Gen Comparison*

The χ^2 surfaces for the ATLAS and Next²Gen models are shown in Figures 3 and 5. As there are three input parameters, $T_{\rm eff}$, $\log g$, and metallicity for each model, we hold the least important constant, and show χ^2 versus the other two. This results in two fairly similar-looking surfaces. In both cases, $T_{\rm eff}$ is the most important parameter in determining χ^2, with the metallicity and surface gravity playing far more subordinate roles. Additionally, while the true $\chi^2_{\rm min}$ for the Next²Gen models is beyond the range in parameter space that we investigated, the flattening of the χ^2 surface indicates that it is not very far away. Both the ATLAS and the Next²Gen models are most consistent with a star of $T_{\rm eff} \sim 4700$ K, $\log g = 2.5$–3.0, and metallicity around -0.3. Finally, we are able to directly compare these two atmospheric models at $T_{\rm eff} = 4000$ and 4500, $\log g = 2.5$, and metallicity $+0.3$. Using our error bars as the metric of comparison, the worst disagreement is $\sim 3\ \sigma$, for $r < 0.3$ at $T_{\rm eff} = 4500$. In all other regions the two profiles tend to disagree by $\lesssim 1\ \sigma$.

4.6.6. *Model Atmosphere-Microlens Profile Comparison*

As we have just shown in § 4.6.5, the atmospheric models both seem to prefer a K1 star. It is therefore important to ask whether our observations are biased and we are

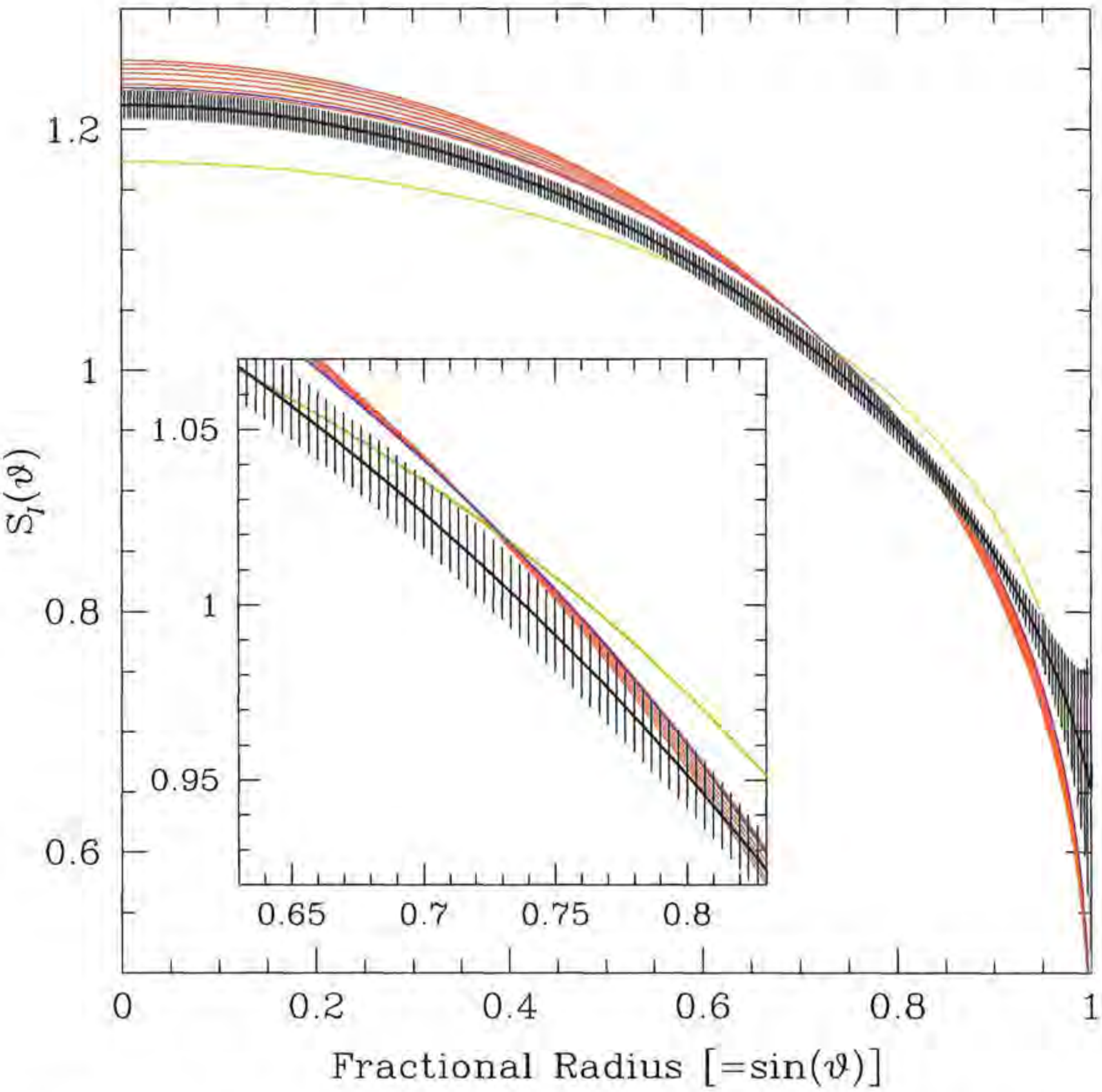

FIG. 8.—Brightness profile in the I band. The black line and shading are EROS BLG-2000-5 and its associated 3 σ error envelope. The red lines give Next[2]Gen models at $\log g = 2.5$ and $[M/H] = +0.3$ for T_{eff} between 4000 and 4600 K, in 100 K increments with the lowest-temperature model the most limb darkened (i.e., the curve that is the brightest in the center and dimmest at the limb). The blue line corresponds to the best-fit Next[2]Gen model at $T = 4600$ K, $\log g = 2.5$, and $[M/H] = -0.25$. Also given is the I-band curve of the Sun in green. As can be seen, there is a point that all the model curves share with the Sun at approximately $(r, S_I) = (0.73, 1.02)$. This fixed point is the same as the one that the ATLAS models share (but the microlensing-determined profiles do not) and is not apparent in the (c_λ, d_λ) formalism.

expecting the wrong type of star. In principle, differential extinction across the field could redden the star more than the clump stars against which it is calibrated (see Fig. 10 of An et al. 2002), thus affecting our photometric estimate of its intrinsic color. However, the spectroscopic analysis yields a source temperature similar to the one we find photometrically.

One should note that reddening has the effect of shifting the observed bands. We find, however, that the measured extinction for EROS BLG-2000-5 $[E(V-I) = 1.3]$ shifts the mean wavelength of the I bandpass by only +100 Å. This shift is about 28% of the difference between the mean wavelengths of I and I_E and only 4% of the difference between I and V. Comparing Figures 7 and 1, one sees that it cannot account for differences between the observations and the atmospheric models. This is partly because the magnitude of the effect is too small and partly because it causes a shift in the wrong direction.

5. CONCLUSION

The observational limb darkening found from microlensing formally disagrees with the limb darkening derived from atmospheric models by many standard deviations. We have argued that this difference is unlikely to be the result of the observations, but it is more likely due to something related to the atmospheric models. It is possible that these models include physics that is not applicable in all surface gravity regimes. It is a testament to the theoretical models that they approximate reality in several bands without any previous physical data. We hope that now that giant stars have a calibration point, much like dwarfs have from the Sun and supergiants have from interferometry, stellar models can continue to improve in all stellar regimes.

We would like to thank Joachim Wambsganss for his comments on this manuscript. We would also like to thank

Amelia Stutz for her work in reducing the H-band data. We thank the EROS collaboration for providing us with their data in advance of its publication. We gratefully acknowledge donations to the Mount Canopus Observatory by David Warren. D. L. F. and A. G. were supported by grant AST 02-01266 from the NSF. Some of the observations were obtained by D. L. D. under NASA grant NAG-10678. B. S. G. was supported by NASA through a Hubble Fellowship grant from the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555.

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MARCH 2004

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

ROSETTA SOARS ON AMBITIOUS COMET INTERCEPT MISSION

Embarking on its epic voyage to gain new insights into comets and the history of our solar system, the Rosetta spacecraft was successfully launched today to rendezvous with a cosmic snowball and deploy a tiny lander onto its icy heart.

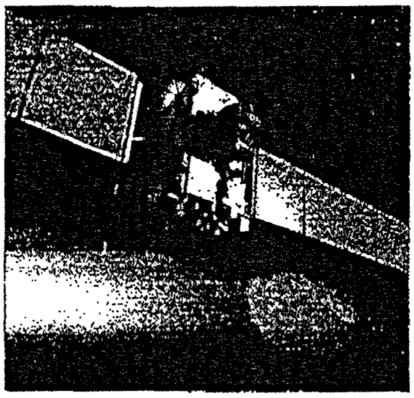
Rosetta aims to give scientists a wealth of knowledge about comets, frozen time capsules from billions of years ago, while helping the public at large wrestle some of the most fundamental questions that humans can ask.

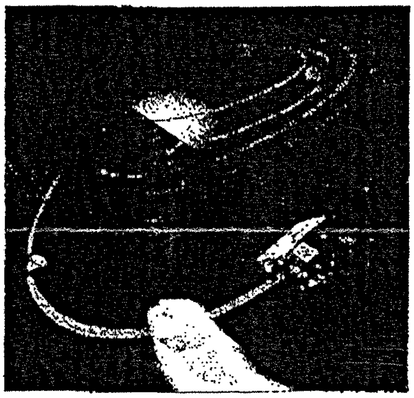
Rosetta will take a circuitous route through the solar system and will arrive back in the vicinity of Earth next March for its first crucial gravity assist fly-by. The probe will reach Mars in March 2007, followed by two additional close approaches of Earth to tweak its course toward Churyumov-Gerasimenko.

Heading further from the Sun and past the asteroid belt, Rosetta will fly near several of these space rocks and study them from a distance of over a thousand miles before entering a hibernation period in mid-2011.

For two-and-a-half years, Rosetta's systems will be completely shutdown with the exception of its primary computer and radio receivers in order to conserve power. Fitted with two solar wings spanning almost 100 feet, the spacecraft will be the first to fly near the orbit of Jupiter and rely entirely on solar power.

Rosetta will also undergo a number of other extended periods of





inactivity between key mission events during the journey to Churyumov-Gerasimenko to relieve manpower and electrical constraints.

Power production is strained for Rosetta because it will be traveling over 500 million miles from the Sun, where light levels are only four percent of those found on Earth.

Controllers will bring Rosetta back to life in early 2014 for a thruster firing to slow the probe's approach to the comet before entering orbit and beginning its mapping and scientific mission to characterize the surface.

By the end of the summer in 2014, Rosetta will be in orbit around Churyumov-Gerasimenko and science operations should be in full swing. A major priority will be the determination of favorable landing sites for a small 220-pound lander carried aboard Rosetta named Philae.

The three-legged Philae will touch down on the surface in November 2014, firing a harpoon to keep the tiny craft anchored on the comet so it doesn't float away in the weak gravitational field. It will snap high-resolution pictures and acquire data about the comet's organic crust and molecules for transmission up to the orbiter for later relay to Earth.

Operating at least one week, perhaps significantly longer, Philae's instrument suite even includes a tiny drill that can bore a few inches into the comet for subsurface investigations.

Together the orbiter and lander will observe the traits and changes the comet goes through as it approaches

ROSETTA STORY (CONT)

the Sun. Officially, the mission is slated to come to conclude in late 2015.

Comet Churyumov-Gerasimenko was discovered in 1969 and is considered a dusty comet that is roughly two by three miles in diameter. The Hubble Space Telescope was chartered to observe the comet for 21 hours in March 2003 to gather more specific details about Churyumov-Gerasimenko to allow project officials to decide whether to pursue it as a potential target.

The Rosetta spacecraft will be able to make observations from as close as 2 kilometers (1.2 miles).

Scientists believe comets are made of the very same primitive materials that were present when the Sun and the solar system were formed an estimated 4.6 billion years ago.

Comets are balls of ice and rock believed to be formed far beyond the orbit of Pluto where conditions are cold and dark, much like they were as the solar system was born. Some of these objects are drawn toward the inner solar system and they become comets — giving us a unique view of almost the same primordial materials that played such important roles in the formation of the Sun and the planets.

Rosetta gets its name from the stone tablet found by French soldiers in Egypt in 1799 that contained the key to deciphering Egyptian hieroglyphics. Scientists hope this mission may unveil the mysteries surrounding how our planet and life came to be as we know it today.

ASTRO NEWS

ROVER CONFIRMS PAST LIQUID WATER ON MARS

NASA's Opportunity rover, studying exposed bedrock in the crater where it landed by chance in January, has found clear evidence that Mars once supported a wet, habitable environment, one that would have been suitable for life, scientists announced Tuesday.

http://spaceflightnow.com/mars/mera/040302marswater.html

ARE BLACK HOLES FUZZBALLS?

In 1997, the three cosmologists made a famous bet as to whether information that enters a black hole ceases to exist — that is, whether the interior of a black hole is changed at all by the characteristics of particles that enter it.

http://spaceflightnow.com/news/n0403/27fuzzball/

SPIRIT LOOKS DOWN INTO CRATER AFTER REACHING RIM

NASA's Spirit has begun looking down into a crater it has been approaching for several weeks, providing a view of what's below the surrounding surface.

http://spaceflightnow.com/mars/mera/040311crater.html

MERCURY ORBITER UNDERGOES FINAL LAUNCH PREPS

NASA's MESSENGER spacecraft, the first Mercury orbiter, has arrived in Florida in advance of its May 11 launch a Boeing Delta 2 rocket. The "MESSENGER" name is short for MErcury Surface, Space ENvironment, GEochemistry, and Ranging.

http://spaceflightnow.com/news/n0403/10messenger/

NASA CREATES PORTRAIT OF LIFE AND DEATH IN THE UNIVERSE

In a small galaxy lies a luminous cloud of gas and dust, called a nebula, which houses a family of newborn stars. If not for the death of a massive star millions of years ago, this stellar nursery never would have formed.

http://spaceflightnow.com/news/n0403/09spitzer/

OPPORTUNITY ROVER CARVES ANOTHER HOLE IN BEDROCK

After its earlier attempt stalled, Opportunity has successfully used the Rock Abrasion Tool to grind a 3.1 millimeter-deep hole in the "Mojo 2" target on "Flatrock."

http://spaceflightnow.com/mars/mera/status.html

HUBBLE'S DEEPEST VIEW EVER UNVEILS EARLIEST GALAXIES

Astronomers today unveiled the deepest portrait of the visible universe ever achieved by humankind. Called the Hubble Ultra Deep Field, the million-second-long exposure reveals the first galaxies to emerge from the so-called "dark ages," the time shortly after the big bang when the first stars reheated the cold, dark Universe. The new image should offer new insights into what types of objects reheated the Universe long ago. http://spaceflightnow.com/news/n0403/09deepfield/

ROVERS WATCH SOLAR ECLIPSES BY MARTIAN MOONS

NASA's Mars Exploration Rovers have become eclipse watchers. Opportunity is the first space probe to see moons pass in front of the sun from the surface of another world.

http://spaceflightnow.com/mars/mera/040308eclipse.html

X-RAYS FROM SATURN POSE PUZZLES FOR SCIENTISTS

The first clear detection of X-rays from the giant, gaseous planet Saturn has been made with NASA's Chandra X-ray Observatory. Chandra's image shows that the X-rays are concentrated near Saturn's equator, a surprising result since Jupiter's X-ray emission is mainly concentrated near the poles. Existing theories cannot easily explain the intensity of distribution of Saturn's X-rays. http://spaceflightnow.com/news/n0403/08saturnxray/

POVG MEETING - MINUTES

Perth Observatory Volunteer
Group Incorporated.
Minutes of Meeting.
February 23rd 2004.

Present.
J Alcroft. J.Milner. L.Martin.
J.Morris. J.Biggs. G.Lowe.
T.Beston. T. Beardsmore.
B.Hollebon. V.Levis. M.Freeman.
M.Haslam. S.Schediwy. B.Harris.
K.Kotze. F.Bilki.

Apologies.
J.Bell. E.Walker. G.Coletti.
D.Emrich. V.Smith. R.Tonello.
D.Alderson.

Meeting Opened at 7.13pm.

Minutes of the Previous Meeting.
Agreed as a true and correct record.

Moved T.Beston. Seconded B.Harris

Business arising from the Minutes.
J.Morris reported that there had been some response to the Newsletter put out to Members of A.C.R.O.D , a small number of handicapped people had visited the Observatory. G.Lowe commented on the time consuming aspect of using the Pantagraph . There was some discussion of using the Cameras and T.V. now that we had two Planets available.

Treasurer's Report.
The Bank balance remained at $210.33

General Business.
J.Biggs stated that Rick.Tonello had been appointed to replace Tom Smith. Arrangements for the Summer Lecture on March 7th were in hand.
The Organising of the field night for the Japanese group would require several
Volunteers, together with as many Teleseopes as possible, T.Beardsley stated that
whilst he might not be able to attend he had 2 suitable Telescopes that he was willing
to provide.
J.Biggs stated that he would be on Long Service leave from March 1st for 12 weeks
Chairman M.Freeman Tabled a proposed program, {see attached Document } for the trip to various impact Craters. After considerable discussion it was agreed that firm bookings from volunteers intending to go on the trip, would be required by the end of March and that a small committee consisting of M.Freeman, B.Harris, and F.Bilki, would oversee the arrangements. The second week in September for a 5 day trip appeared to suit most members, once firm bookings had been received from members, any available spare seats would be offered to anyone else who wished to join the trip.
There being no further General Business the meeting closed at 8.30pm

Next Meeting March 15th

PHASES OF THE MOON FOR 2004 (WA TIME)

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	Jan 15 12:46
Jan 22 05:05	Jan 29 14:03	Feb 6 16:47	Feb 13 21:40
Feb 20 17:18	Feb 28 11:24	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	Apr 5 19:03	Apr 12 11:46
Apr 19 21:21	Apr 28 01:32	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hp[illegible]01.htm

2004 VOLUNTEER TRAINING & MEETING NIGHTS

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

Apr 19
May 17
Jun 14
Jul 12
Aug 9

PERTH OBSERVATORY VOLUNTEERS GROUP INC.

OBSERVATORY'S VOLUNTEER ACTIVE MEMBER LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
Peter Crake
Trevor Dunn
David Emrich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
James Healy
Bert Hollebon
Karen Kotze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Kylie Ralph
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Robert Taylor
Patricia Turner
Elaine Walker
Sandra Walker
Matthew Zengerer

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Tom Smith	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
David Tiggerdine	Maintenance Person
Sheryle Smith	Cleaner

POVG VOLUNTEERS

Mike Freeman	Chairperson
Karen Koltze	Vice Chair
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator

(contact bevan on ngc2070@bigpond.com)

Jeff Alcroft	Newsletter Editor

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to.
To join simply send your email address to BEVAN HARRIS at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

POVG
Perth Observatory Volunteers Group

April 2004

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

A very busy month for the Perth Observatory

Last March was one of the busiest months ever undertaken at Perth Observatory, and could not have been managed without the help of many of the volunteer group. Some of the events we have covered are:

Summer Lecture

10 volunteers rolled up to help out. Over 170 people attended what was one of the best lectures ever, given by Ray Norris of CSIRO. Afternoon rain dampened the lawns and raised Peter's blood pressure as we toyed with a change of venue. However, the Sun came out, and although it was quite cold, the whole event went off very well. As a new feature, we opened the telescopes afterwards, and this was well received by the masses, who were still lining up at 10:30pm.

Planetarium Opening

8 vollies and 5 staff attended the initial screening at this terrific venue. The all new digital system can do wonderful things, and is quite breathtaking. The staff at Scitech - Jacquii Milner is now one of them !! - are still learning how to use it, and they will be using prerecorded programs as well. Peter & Janet from the Obs attended the official opening on April 5, with red carpet, various VIPs, as well as a smattering of politicians and their hangers on.

Muscular Dystrophy Association Walk

Was held on a stinking hot afternoon and was very disappointing. The hottest day of the year kept people away, and only around 300 turned up to walk the bridges with the kids in wheelchairs.

The Byford Japanese night

Saw Perth Obs staff and 10 volunteers entertain 397 japanese tourists with 10 telescopes in a paddock from 11pm until 2am on March 28/9. This was truly a Volunteer and staff effort, as the Observatory did not have sufficient resources to cover requirements. We hired a bus, used all the telescopes we could muster, and eventually got to bed pretty much at dawn. Several had to attend day jobs as well, although many took the day off.

Dave tried out his Internet Japanese lessons to good effect, Val coped well with the disaster of having her power lead pulled out mid stream, while the rest of us smiled and pointed a lot. The green pointers were terrific for this. Quite a lot of them laid on their backs in the dark just looking at the starts. The occasional meteor was met with many ohhaahhs.

Astrofest

Finally, the Astrofest on April 3 was clouded out. Held at Trinity on a hot humid afternoon and evening, this was pretty much a flop, as cloud during the day meant people stayed away, and even though it cleared a little after dark, it was too little too late. Astrofest has been successful in past years, but the last 2 have been disasters.

Observatory Visitors

As well as all these events, there were almost 800 night visitors on 22 tours in March as well as 400 day visitors on 15 day tours. Thank goodness we now have Rick Tonello on board - although he has been working on his own for much of the month doing astronomy field nights at places like Beacon.

Praise for Pantagraph

Finally, Greg & Peter entertained a group of 12 frail and aged people in late March, using the pantagraph. Several were in wheelchairs, the rest probably should have been, and they were taken up to the telescopes by bus. One was 92, the only man in the group was 94, and the rest were all over 75. It was a really good evening, given the restrictions these folk have. The pantagraph is really a useful tool !!

Thanks to Staff & Vollies

Thanks to all the volunteers who have assisted us over the summer.

I tell you, Easter never looked so good !!

Peter Birch. Acting Director.
Astronomy is Looking up !!

2003-04 Chairperson's Report

THE YEAR IN REVIEW - 2003-04
Chairman's report to the Perth Observatory Volunteer's Group

As the 2003-2004 Observing Season draws to a close, so the Vollies Group looks to its Annual General Meeting, and the coming quieter Winter period.

The year did not seem to be as active as the previous couple, and it could perhaps be regarded as one more of consolidation, with no major purchases and unveilings. However, I believe we can be quite comfortable in that it has been successful as far as providing our support to the Observatory and helping to introduce many of the public into the wonders and awe of the night skies.

One highlight for the year was the close approach of Mars, and the great impetus that astronomy had. We felt it through the very early and strong start to the year, and this led to records, both in numbers of visitors and in our commitment to volunteering.

The major downturn was the loss of founding and extremely energetic Chairman Trevor, now in greener (literally) pastures in the Mother Country. Trevor was an eminently suitable inaugural Chairman, with the enthusiasm, drive and vision to put our Group on a firm path. I believe that the Group owes him a big debt of thanks for all he did. Another departure of note was that of Tom Smith, "worker" at the Observatory who was always a friendly face and a helper with ideas and supporter of the Vollies.
To help with the volunteering, we had a number of most-welcome new vollies; Trevor Beardsmore, Guiseppe (Joe) Coletti, Dave Emrich, Don Hartley, Erin Lalor, Elaine Walker, and Matt Zangerer. Hope you all feel welcome and a part of our group.

Peter Birch, in the absence of Jamie Biggs, has already commented upon the statistics for the year at our March Vollies Meeting. It is worth re-iterating some of his numbers, preliminary though they are until the season is completed.

To the end of February, total number of visitors was 5235, bettering the previous best year (2001-02) of 3889, and indicating that the total number of visitors for this year could be over 1200 more than the previous best. The reason for this being largely through the season getting off to a huge start with 1500 or so attending in August to October to observe Mars, a period that in previous years has seen only a handful of people. (Note: figures not shown).

Figure 1 shows the progressive numbers for the past three years. How did that contribute to the vollies efforts? Figure 2 shows that for the September quarter, the number of hours the vollies gave were double that of the previous years, (sorry that I do not have figures beyond that quarter - we will have to await reduction of the data for the rest of the season, but it should be a good contribution to the operation of the Observatory.

One of the goals of the previous years was to achieve greater numbers of visitors with disabilities. We have seen a number this year.

Vollies have been seen helping to assist them in the wheelchairs. Using the pantograph and helping them to manoeuvre to get a clear look at the stars. Thanks to John Morris for assisting in this.

One purchase we made was the buying of two more Jarrah benches for the viewing area. These have been well used on the nights.

The Observatory expressed its thanks to the Vollies in giving many of us a visit to New Norcia, to look through the European Space Agency's deep space tracking and communications facility, and to enjoy lunch in the historic hotel in the town. Thirty two vollies and staff attended to experience "The Dish", and the feeling how the rain ran off the superstructure in very large drops!

A number of other events were attended, either as part of the audience or helping Observatory staff to present at events, such as the Summer Lecture, with:

- Ray Norris talking bout The Void at the End of the Universe;
- Don Kurtz at his talk on the Music of the Spheres;
- Astrofest;
- helping over 300 Japanese to enjoy our views of the skies at Byford, using vollies' own telescopes to cope with the numbers.

And on looking into the future, we have the forthcoming "off" season to regroup our ideas and work out where we are going. We have the promise of the trip by a small number to the Shoemaker Impact Structure and other impact sites in September. Questions I would like to pose to members are: What do we want?,, Where are we going?, What can we do to help ourselves and to help the Observatory in providing improved experiences of the viewing of our night skies?.

Even more fundamentally, "Is there a need for a grand plan"?, or "Are we succeeding really well by continuing to just help the Observatory reveal to our fellow Perthites the marvels of our night skies.

Mike Freeman. Chairman. April 2004.

SPECIAL ANNOUNCEMENT:
Join us to watch the total eclipse of the Moon through a telescope.
Perth Observatory (May 5),

On the MORNING of May 5, the Moon will pass through the Earth's shadow. It sTarts at 0151, middle at 0430, ends after sunup. Details are all in the handbook on p 59. The Observatory will be open for all volunteers and their families etc to come along and watch through telescopes.

BYO everything. Please RSVP Peter or Greg that you are coming.

POVG Meeting: Minutes

Perth Observatory Volunteer Group Inc
Minutes of Meeting: March 15 2004.

Present B.Hollebon. R.Boelen. D.Emrich. J.Milner. T.Beardsmore. E.Walker. T.Beston. M.Haslam. L.Robinson. M.Freeman. J.Morris. P.Birch. G.Lowe. A.Williams

Apologies. A.McNaughton. L.Bell. S.Schediwy. G.Colletti. J.Bell. R.Tonello. F.Bilki. V.Smith. V.Semmler. E.Cowlishaw. J.Alcroft.

Confirmation of minutes. Agreed as a true and correct record. Moved T.Beardsmore Seconded T.Beston.

Business Arising from the Minutes. None

Treasurers Report.
The Financial remains unchanged with $210.33 in the account.

General Business. Chairman M.Freeman stated that he had 7 people confirmed for the Impact Craters trip. There 13 more seats available, deposits would be required to be paid early in June.
The Minutes showed that last year the A.G.M was held on March 31st and 28 days notice was required to be given to all members, Notice is hereby given that the A,G,M for this will be at the next meeting on April 19th.
P.Birch reported the Japanese Star Viewing night would be on Sunday 28th March, members attending should be at the Observatory by 8pm to travel by Bus to the site in Byford.

P.Birch stated that preparations were being made to have an Observatory Web site , it was Moved D.Emrich , seconded M.Haslam that the Camera's belonging to the Volunteer Group could be used ,if required. P.Birch thanked all members who assisted at the Lecture night, which despite the cold weather was very successful. He then showed members on the Screen details of the two Comets due in April, one of which should be at Magnitude 4. This was followed by some statistics on Tour attendances and the amount of time given by Volunteers in achieving those figures. The total hours for each
Volunteer are forwarded to C.A,L.M. for inclusion in their Annual Report and entitle those achieving a certain level a Free Pass into all National Parks.
A.Williams then showed a short film , demonstrating the Launch of the Mars Landers and how they operated once they reached the surface of Mars.

There being no further General Business the meeting closed at 8.24pm.

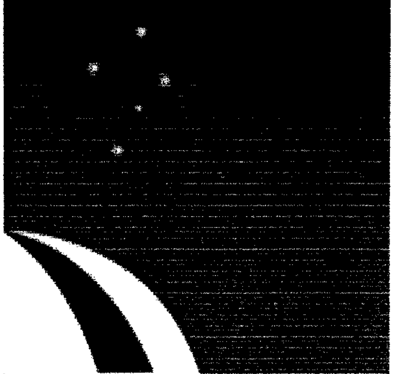
Next Meeting April 19th
7.00pm..A.G.M.

PHASES OF THE MOON FOR 2004 (WA TIME)

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	Jan 15 12:46
Jan 22 05:05	Jan 29 14:03	Feb 6 16:47	Feb 13 21:40
Feb 20 17:18	Feb 28 11:24	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	Apr 5 19:03	Apr 12 11:46
Apr 19 21:21	Apr 28 01:32	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hpc5mn03.htm

2004 VOLUNTEER TRAINING AND MEETING NIGHTS



Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated.
Jamie Biggs. Govt Astronomer

May 17
Jun 14
Jul 12
Aug 9

Perth Observatory Volunteers Group Inc.

Observatory's VOLUNTEER Active Member LIST

Jeff Alcroft
Dick Alderson
Jeanne Bell
Trevor Beardsmore
Lyall Bell
Frank Bilki
Tony Beston
Ric Boelen
Eve Cowlishaw
Giuseppe Coletti
David Emrich
Keith Ford
Marcel Fortsch
Mike Freeman
Lynda Frewer
Bevan Harris
Don Hartley
Mark Haslam
Bert Hollebon
Karen Kotze
Erin Lalor
Vic Levis
Rob Loney
Andrew MacNaughtan
Len Martin
Jacquie Milner
John Morris
Lloyd Robinson
Sascha Schediwy
Val Semmler
Vera Smith
Patricia Turner
Elaine Walker
Sandra Walker
Matthew Zengerer

Perth Observatory Staff

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Rick Tanello	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
Marc Appelhof	Maintenance Person/Cleaner

POVG Volunteers

Mike Freeman	Chairperson
Karen Koltze	Vice Chairperson
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator (contact: ngc2070@bigpond.com)
Jeff Alcroft	Editor (contact: callides@iinet.net.au) or through newsgroup

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pic simply post them on the newsgroup for all (newsgroup members only) to enjoy or respond to. To join simply send your email address to Bevan Harris at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

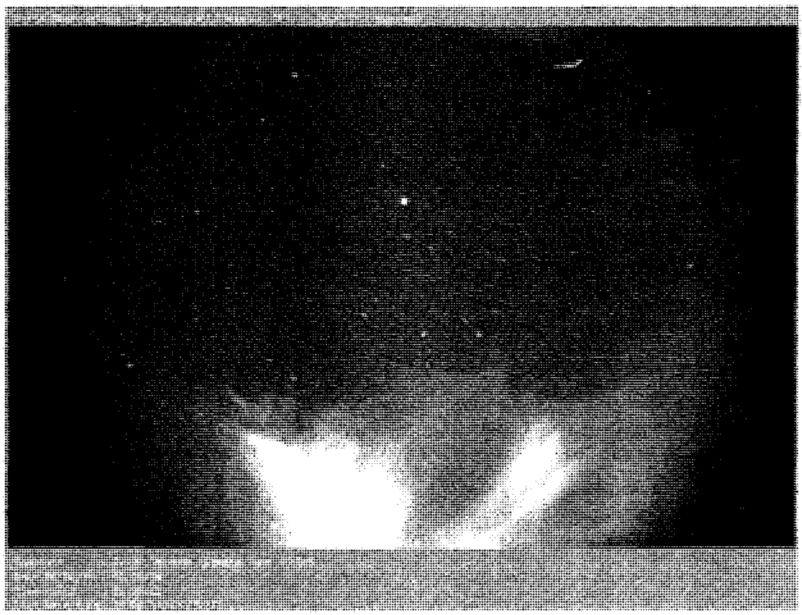
POVG
Perth Observatory Volunteers'Group

May 2004

VollieNews

Newsletter of the POVG-The Perth Observatory Volunteers' Group Inc.

OBSERVATORY'S NEW ALL-SKY CAMERA TAKES OFF



The Observatory all sky camera has started operating, and so far all has gone well. Comet NEAT shows up OK under Canopus, and the camera appears to have enough sensitivity. Orion Neb is an easy object as well.

The camera is on the roof of the Observatory, and is set at a specific Alt / Az and left running unattended. Various small problems are still to be remedied.

Imagery is available through the Perth Observatory Web site.

This site is undergoing major surgery right now, and while it is basic, it loads very quickly. www.wa.gov.au/perthobs

The cloud of the last few days has hindered development, but the system will be available for mid May.

Cheers. Peter Birch

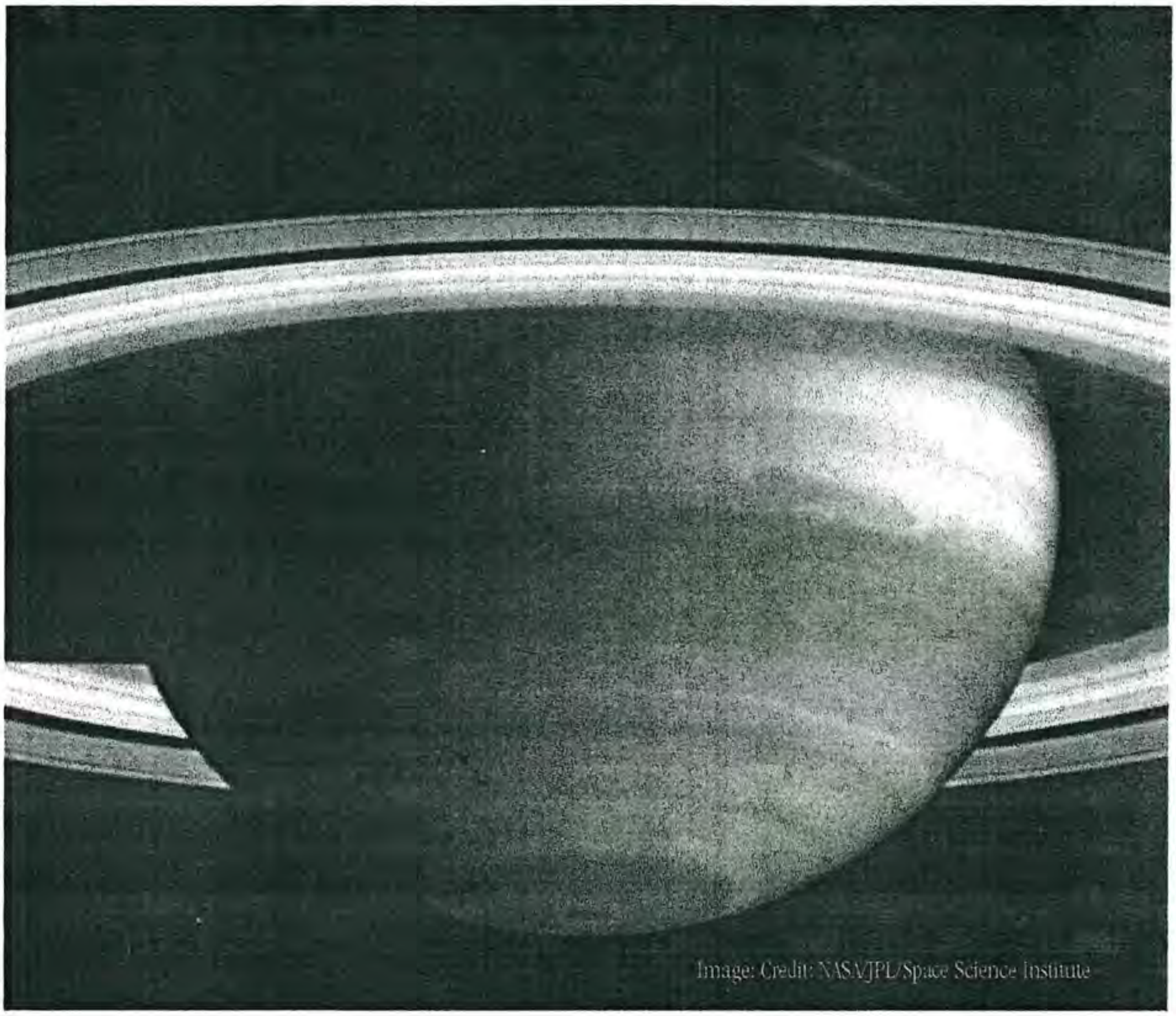
TOTAL ECLIPSE OF THE MOON

The Total Lunar Eclipse was enjoyed by all under clear skies, with a balmy 15 degree minimum. This was quite a dark eclipse, with the moon not getting as red a seen previously. As a bonus, there were a lot of meteors from the Eta Aquariids.

Second bonus was the sight of Comet Linear 2002T7 in the east during totality. Bright - 2nd magnitude - coma, and a 4degree tail visible in binoculars. Pictures on show at the next vollie night. Cheers Peter Birch.

In this issue:

Cassini's latest image shows bands of clouds and lace



As Cassini nears its rendezvous with Saturn, new detail in the banded clouds of the planet's atmosphere are becoming visible.

Cassini began the journey to the ringed world of Saturn nearly seven years ago and is now less than two months away from orbit insertion on June 30. Cassini's narrow-angle camera took this image on April 16, 2004, when the spacecraft was 38.5 million kilometres (23.9 million miles) from Saturn.

Dark regions are generally areas free of high clouds, and bright areas are places with high, thick clouds which shield the view of the darker areas below. A dark spot is visible at the south pole, which is remarkable to scientists because it is so small and centered. The spot could be affected by Saturn's magnetic field, which is nearly aligned with the planet's rotation axis, unlike the magnetic fields of Jupiter and Earth. From south to north, other notable features are the two white spots just above the dark spot toward the right, and the large dark oblong-shaped feature that extends across the middle. The darker band beneath the oblong-shaped feature has begun to show a lacy pattern of lighter-coloured, high altitude clouds, indicative of turbulent atmospheric conditions.

The cloud bands move at different speeds, and their irregularities may be due to either the different motions between them or to disturbances below the visible cloud layer. Such disturbances might be powered by the planet's internal heat; Saturn radiates more energy than it receives from the Sun.

The moon Mimas (396 kilometres, 245 miles across) is visible to the left of the south pole. Saturn currently has 31 known moons. Since launch, 13 new moons have been discovered by ground-based telescopes. Cassini will get a closer look and may discover new moons, perhaps embedded within the planet's magnificent rings.

This image was taken using a filter sensitive to light near 727 nanometers, one of the near-infrared absorption bands of methane gas, which is one of the ingredients in Saturn's atmosphere. The image scale is approximately 231 kilometres (144 miles) per pixel. Contrast has been enhanced to aid visibility of features in the atmosphere.

http://spaceflightnow.com/news/n0405/14cassinisaturn/
CICLOPS/SPACE SCIENCE NEWS RELEASE
Posted: May 14, 2004.

'Smoking gun' evidence of giant meteor collision

Evidence is mounting that 251 million years ago, long before the dinosaurs dominated the Earth, a meteor the size of Mount Everest smashed into what is now northern Australia, heaving rock halfway around the globe, triggering mass volcanic eruptions, and wiping out all but about ten percent of the species on the planet.

The "Great Dying," as it's called, was by far the most cataclysmic extinction event in Earth's history, yet scientists have been unable to finger a culprit as they have with the dinosaur extinction. A new paper published in Science, however, claims to identify the crater made by that meteor, and it builds upon an ongoing body of evidence by researchers at the University of Rochester and the University of California at Santa Barbara (UCSB), that points the finger for the Great Dying squarely at the heavens.

"This is very likely the impact site we've been looking for," says Robert Poreda, professor of earth and environmental sciences at the University of Rochester. "For years we've been observing evidence that a meteor or comet hit the southern hemisphere 251 million years ago, and this structure matches everything we've been expecting."

In 2001, Poreda and Luann Becker, research scientist in geological sciences at UCSB, announced that they had detected in 251-million-year-old strata, specific isotopes of helium and argon trapped inside buckyballs-a cage-like formation of carbon atoms-that could only have come from space. Since they were laid down in this same strata around much of the globe, the implication was that a giant meteor had struck the Earth, vaporized, and settled around the southern hemisphere. This past November, the same three authors-Poreda, Becker, and Asish Basu, professor of earth and environmental sciences at the University of Rochester-published another article in Science that found actual pieces of the meteorite that struck the Earth in the same global strata.

Many experts scoffed at the idea of a giant meteor causing the mass extinction between the Permian and Triassic periods, but Poreda points out that many also scoffed at the idea that a meteor was responsible for a later and lesser extinction at the Cretatious/Tertiary boundary that marks the end of the dinosaurs. Now, the impact theory is largely accepted.

The team knew that the chances of finding the crater, even one from an impact large enough to nearly wipe out life on Earth, would be difficult because the majority of the Earth is covered by ocean. Had the meteor struck there, its telltale crater would have long ago disappeared. As luck would have it, an oil-drilling exploration team in 1970 found a "dome" in the area of Bedout, just off the northwestern coast of Australia. Now covered by 2 miles of sediment, this area was most likely dry land 251 million years ago.

Frequently, such domes herald large oil deposits, but in this case the drilling team found only what it labelled as "volcanic rock." The core samples were shelved and forgotten for 25 years, until in 1995 a report in a journal aimed at the oil industry mentioned that the rock might have been formed from a meteor impact.

It wasn't until Becker caught wind of the "volcanic" find in 251 million year old rock that the team members began to think they'd found their smoking gun. Poreda and Becker investigated the core samples first hand. "They were unlike any volcanic rocks I've ever seen," says Poreda. "In a volcanic explosion you may find angular pieces of rock that are broken apart mixed with the volcanic melt. In these samples, though, the rocks were shock melted from an impact. We left convinced Bedout was our crater."

The clincher was the presence of a feldspar glass in the shape of a feldspar crystal. Such features do not form in volcanic eruptions. Many of the plagioclase samples showed evidence of sustaining an intense shock, meaning the meteor likely hit a bed that contained feldspar crystals, shock-melted their interiors, melting their insides the way a microwave oven might bake a potato's inside while leaving the outer areas cool.

"Once we looked at Bedout with the understanding that it was likely a crater, the geophysics just fell into place," says Poreda.

Geophysical analysis shows the rock strata underlying the dome at Bedout is fractured exactly the way the team expected-showing rock strata older than 251 million years old broken apart, with younger rock above laid down without the fractures. Simulations of a six-mile wide rock striking the area suggest a crater rim should be visible about 60 miles from the central dome, and despite the extreme age of the impact site and the rearrangement of continental plates since then, there is evidence of a rim at that distance. The team has plans to explore the geophysical outlay of the region with more scrutiny.

Coincidentally, the Bedout crater, at 120 miles across, is almost exactly the same size as the Chicxulub crater in the Caribbean that has been identified as the impact site of the meteorite that dealt the dinosaurs their death blow. It's likely that the bodies that struck at each site were of the same size and travelling at similar speeds.

Along with both impacts correlating strongly with two of the greatest extinctions in Earth's history, the team has found that massive lava flows in two different parts of the world have similar correlations. Basu showed that massive lava flows in India date back precisely to the Chicxalub impact, and recently he also reported that similar giant lava flows in Siberia coincide exactly with the Bedout impact.

"There have been five mass extinctions throughout the Earth's history," says Poreda. "Now we have very strong evidence that massive meteor impacts happened precisely at two of those extinctions.

UNIVERSITY OF ROCHESTER NEWS RELEASE
Posted: May 14, 2004
"http://spaceflightnow.com/news/n0405/14impact/

Astro News

LATEST CASSINI IMAGE SHOWS BANDS OF CLOUDS AND LACE

As Cassini nears its rendezvous with Saturn, new detail in the banded clouds of the planet's atmosphere are becoming visible. Cassini began the journey to the ringed world of Saturn nearly seven years ago and is now less than two months away from orbit insertion on June 30.
http://spaceflightnow.com/news/n0405/14cassinisaturn/

DYING STAR SCULPTS RUNGS OF GAS AND DUST

A new image, taken with NASA's Hubble Space Telescope, reveals startling new details of one of the most unusual nebulae known in our Milky Way.
Catalogued as HD 44179, this nebula is more commonly called the "Red Rectangle" because of its unique shape and colour as seen with ground-based telescopes.
http://spaceflightnow.com/news/n0405/11hubble/

GIANT GALAXY'S VIOLENT PAST COMES INTO FOCUS

Long-exposure images of the giant elliptical galaxy M87 by NASA's Chandra X-ray Observatory, together with radio observations, have provided spectacular evidence of repetitive outbursts from the vicinity of the galaxy's supermassive black hole.
Magnetised rings, bubbles, plumes and jets ranging in size from a few thousand to a few hundred thousand light years point to ongoing violent activity for hundreds of millions of years.
http://spaceflightnow.com/news/n0405/10chandra/

XMM-NEWTON DETECTS X-RAY 'SOLAR CYCLE' IN DISTANT STAR

For years, astronomers have wondered whether stars similar to the Sun go through periodic cycles of enhanced X-ray activity, like those often causing troubles to telephone and power lines here on Earth. Europe's X-ray observatory XMM-Newton has now revealed for the first time a cyclic behaviour in the X-ray radiation emitted by a star similar to the Sun.
http://spaceflightnow.com/news/n0405/10solarcycle/

GRAVITY PROBE B UPDATE

Gravity Probe B - a NASA experiment to test two predictions of Albert Einstein's Theory of General Relativity - continues to perform well. Launched April 20 from Vandenberg Air Force Base, Calif., the spacecraft remains in its science mission orbit within the plane of its guide star, IM Pegasi, and program managers are expecting a smooth and successful transition into the science phase of the mission.
http://spaceflightnow.com/news/n0405/10gbpstatus/

TWO EXTREMELY HOT EXOPLANETS CAUGHT IN TRANSIT

A European team of astronomers are announcing the discovery and study of two new extra-solar planets. The observations were performed in March at the Paranal Observatory in Chile.
http://spaceflightnow.com/news/n0405/07exoplanet/

CLOSER TO THE MONSTER

Fulfiling an old dream of astronomers, observations with the Very Large Telescope in Chile have now made it possible to obtain a clear picture of the immediate surroundings of the black hole at the centre of an active galaxy.
http://spaceflightnow.com/news/n0405/06blackhole/

CASSINI SPIES ON TITAN

The veils of Saturn's most mysterious moon have begun to lift in Cassini's eagerly awaited first glimpse of the surface of Titan, a world where scientists believe organic matter rains from hazy skies and seas of liquid hydrocarbons dot a frigid surface.
http://spaceflightnow.com/news/n0405/06cassinititan/

STUDY MAY CAST DOUBT ON 1996 REPORT OF PAST MARS LIFE

The scientific debate over whether a meteorite contains evidence of past life on Mars continues to intensify, with colleagues of the team that announced the possibility in 1996 revealing new findings that may cast doubt on some of that earlier work.
http://spaceflightnow.com/news/n0405/05marslife/

NASA'S GENESIS SPACECRAFT ON FINAL LAP TOWARD HOME

The Genesis spacecraft flew past Earth a few days ago in a loop that puts it on track for home - and a dramatic mid-air recovery Sept. 8. The mission was launched in 2001 to capture samples of the solar wind for return to Earth-bound scientists.
http://spaceflightnow.com/news/n0405/05genesis/

HUBBLE TELESCOPE SHOWS DEMISE IN ICE AND FIRE

The Bug Nebula is one of the brightest and most extreme planetary nebulae known. At its center lies a superhot, dying star smothered in a blanket of hailstones. A new Hubble image reveals fresh detail in the wings of this cosmic butterfly.
http://spaceflightnow.com/news/n0404/30fireandice/

PAPER PROBES PULSAR PAIR

The only known gravitationally bound pair of pulsars – extremely dense, spinning stars that beam radio waves -- may be pirouetting around each other in an intricate dance.
http://spaceflightnow.com/news/n0404/30pulsarpair/

NASA'S GRAVITY PROBE IN ITS SCIENCE MISSION ORBIT

In its first week on orbit, Gravity Probe B has achieved many successes that will ensure a smooth transition into the science phase of the mission and the best possible experimental accuracy. The spacecraft has already achieved a science mission orbit, within the plane of the Guide Star, IM Pegasi, and its inclination error is six times better than expected.
http://spaceflightnow.com/news/n0404/28gpbstatus/

CLOUDS FROM AIRCRAFT EXHAUST MAY WARM CLIMATE

NASA scientists have found that cirrus clouds, formed by contrails from aircraft engine exhaust, are capable of increasing average surface temperatures enough to account for a warming trend in the United States that occurred between 1975 and 1994.
http://spaceflightnow.com/news/n0404/27clouds/

POVG Minutes - Annual General Meeting

Perth Observatory Volunteer Group Inc
Minutes of Meeting April 19th 2004

Present.

L.Bell. B.Hollebon. L.Martin. A.Mcnaughton. R.Tonnello. J.Alcroft. J.Morris.M.Freeman. R.Boelen. E.Walker. A.Williams. P.Birch. L.Robinson. M.Haslam
J.Milner. G.Lowe. B.Harris. F.Bilki. D.Alderton. G.Coletti.

Apologies.

D.Emrich. T.Beardsmore. T.Beston. V.Smith. K.Kotze.

Meeting Opened at 7.10
Confirmation of Minutes. Agreed as a true and correct record . Moved D.Alderton Seconded R.Boelen

B.Harris stated that his apology for the March Meeting had not been recorded in the Minutes

General Business.

Nil.

Treasurer's Report.
There had been no financial transactions during the past month

A.G.M.

Treasurers Report. B.Harris stated that there had only been 4 financial transactions during the past Year. Monies in the Bank account stood at $210.33, The years accounts would be Audited and signed by the next Meeting

Chairman's Report .

M.Freeman stated that his Annual report was printed in the Newsletter . He wished to thank all the members of the Group for their efforts over the past year and said that he was sure that the volunteers felt as he did, that it was a privilege to assist the Observatory and thanked all members of the Staff for their support. He noted with regret that Tom Smith had left us and welcomed Rick Tonnello.

The Chairman then declared all Committee positions vacant and called for nominations.

G.Lowe reported that he had spoken to Vice Chairman K.Kotze on the phone, who wished it to be noted that due to outside pressures she would not stand for re-election

The following Nominations were received.

Chairman ....M.Freeman. nominated by L.Martin. seconded F.Bilki.

Vice Chairman ...E.Walker. nominated by B.Harris. seconded J.Alcroft.

Secretary....J.Morris. nominated by J.Alcroft seconded B.Hollebon.

Treasurer...B.Harris. nominated by J.Morris. seconded J.Alcroft.

There being no further Nominations the above members were elected unopposed

J.Alcroft agreed to remain Editor of the Newsletter.

The Chairman raised the matter of future activities of the Group and whether the present structure needed to be retained. B.Harris pointed out that there might well be opportunities in the future when the current formation of the Incorporated Group would be an advantage and suggested that we remain with the present format. M.Freeman asked for suggestions for advertising the Shoemaker Impact Crater Trip to groups that might be interested in joining the trip

P Birch .End of Season Report.

P. Birch stated with regret that we were about to lose two long standing members in Trish Turner whose work in the archiving section had been invaluable, and Bert Hollebon who was finding it increasingly difficult to drive at night , he thanked Bert for his efforts over the years and hoped he would still come to the Observatory during the day.

He pointed out to all members just how valuable their efforts were to the Observatory and stressed that without the Volunteer Group the night tours would be impossible to maintain. This year the Tours had generated $120.000, and the total number of hours contributed by the Group was the equivalent of having an additional full time staff member. Members should be aware that they were welcome to bring friends or relatives to the Observatory and have the use of the Telescopes, just contact the Observatory and book a convenient time Peter commented on the opening of the Planetarium and stated that he felt it assist bookings for the night Tours ,but might have some effect on numbers coming to the Observatory during the day.

The planned Observatory Web site would go on line shortly and there was some discussion on using it as an Advertising medium for the Night Tours

There were no dramatic plans for the future, next years program was being worked out, but would be similar in format to this years. It was possible that if the Comets became bright enough we would run Special Comet viewing Tours as we had for Mars , if that was the case there would be a call for members to attend on the relevant nights.

There being no further Business the Meeting closed at 8.10

L.Bell wished it to be noted that he would be absent for the next 4 months.

Rare Transit of Sun by Venus

Put a big red circle around June 8 on your calendar. On that day, you may have a chance to see a celestial event not witnessed by human eyes in 122 years when Venus crosses in front of the Sun.

By the end of May 2004, however, Venus will be rapidly dropping back toward the Sun's vicinity, ultimately to disappear as it makes the transition back into the morning sky. That transition day will be June 8.

Normally, Venus would pass unseen, hidden in the brilliant glare of the Sun. But not this time.

For on this Tuesday in June an Venus will making itself evident as a small black spot slowly moving across the solar disk. Portions of the hours-long transit will be visible from many locations around the world, including parts of Europe and America. Some folks will need to make travel plans, however, to see the show.

RARE OPPORTUNITY

This is among the rarest of astronomical events. In fact, between the years 2000 BC and 4000 AD there are only 81 Venusian "transits," as astronomers call them.

Only five times have humans recorded the passage of Venus in front of the Sun (in 1639, 1761, 1769, 1874 and 1882), although it's not impossible that a transit of Venus might have once been seen by chance in ancient times, near sunrise or sunset.

Astronomer Joseph Ashbrook (1918-1980) wrote in "The Astronomical Scrapbook" (Sky Publishing Corporation, 1984): "For those who witness the transit of June 8, 2004, there comes the awesome thought that not a single human being remains alive that observed the last transit of Venus, in December, 1882."

There is some neat math involved in Venus transits, all related to the predictability of its orbit, which is closer to the Sun than the annual path of Earth.

The circumstances of the transits of Venus repeat themselves with great exactness after a period of 243 years. The intervals between individual transits (in years) currently go as follows: 8 + 121 1/2 + 8 + 105 1/2 = 243. In other words, a pair of transits may occur over a time span of just eight years, but following the second transit, the next will not occur again for more than a century.

Transits of Venus occurred on Dec. 9, 1874 and Dec. 6, 1882. The transit this June is the first one since 1882, but the next will occur 8 years later on June 6, 2012, although this future event will be visible in its entirety only from the Pacific Ocean and the extreme east coasts of Siberia, Japan and Australia (North Americans will see the opening stages before sunset).

Then it will be a long wait once again. On December 11, 2117, Venus will again pass in front of the Sun.

Transits do not occur each time Venus passes from our evening to our night sky because things have to be lined up just right. When a transit occurs, the Sun, Venus and Earth are all in a direct line. But Earth and Venus do not orbit in exactly the same plane around the Sun, so often each planet is either above or below the location that would allow a transit.

Think of it this way: Place two hoops on the ground to represent the orbits of the planets. Place a tennis ball in the middle as the Sun. Now lift one portion of one hoop a few inches off the ground. Only where the opposite side of the lifted hoop touches the ground can you imagine a line that connects all three objects.

LOCATIONS TO WATCH

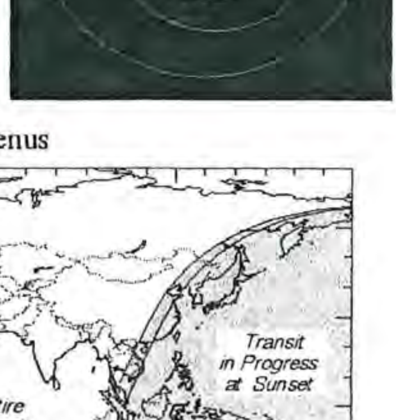
On June 8, the entire transit will last just more than six hours and will be visible in some form across approximately three-quarters of our planet.

Australians will be able to catch the beginning stages before sunset. Europeans will be able to see most, if not all of the transit, starting at around sunrise with the end coming in the early afternoon with the Sun high in the sky. For much of the eastern United States and Canada, the Sun will rise with Venus already on the Sun's disk with the transit nearly over.

Venus transits are readily visible without telescopes or binoculars, but proper protection must be employed. Never look directly at the Sun, or serious eye damage can result. Viewers should use special, approved filters that can be purchased from reputable dealers of astronomy products. Other tricks can be employed, such as pinhole cameras or simple projection methods, to indirectly and safely view the Sun.

When Venus is in transit across the solar disk, the planet appears as a distinct, albeit tiny, round black spot with a diameter just 1/32 that of the Sun. This size is large enough to perceive with the unaided but properly protected eye.

http://www.space.com/spacewatch/venus_transit_040206.html



World Visibility of 2004 Transit of Venus

"Back to Basics - Venus"

Venus has been described since ancient times as both the "morning star" (Phospherus) and the "evening star" (Hesperus) because of its prominent appearance near the Sun. Venus is always bright because it is highly reflective, and it comes closer to Earth than any other planet.
Once called Earth's "sister planet" it is now known that Venus is the closest thing to Hell that you could ever imagine. It is a similar size to Earth and is a rocky body, but in all other respects it is nothing like our comfortable home planet.

With an atmosphere of almost pure carbon dioxide, atmospheric pressure about 90 times that of Earth's, a global temperature of 470°c (higher than Mercury's day side) and clouds of sulphuric acid, you would be simultaneously asphyxiated, crushed, roasted and dissolved. This inhospitable place has only a meagre supply of water - less than 30 parts per million (which probably comes from occasional comet impacts). There is no ocean, and no precipitation (it does not rain sulphuric acid).

When observing Venus with a telescope, you will notice that it appears bland and bright. What you see is not the surface of the planet, but the top of a uniform haze of concentrated acid droplets some 60km deep, which extends to 90km above the surface. Its rotation is unusual in that is takes 243 days to rotate, longer than its 225 day year. Thus any spot on its surface has 122 days of sunlight and 121 days of darkness. Its contra-rotation means the Sun rises in the west and sets in the east.
Venus presents a diverse and puzzling geology. Some of its features are:

* The longest channel in the Solar System (an old lava flow 7,000 km in length - longer than the River Nile)
* Few impact craters, signifying a relatively young surface
* Mountains thought to be "active" volcanoes, supported by plumes of upwelling material under the crust
* Volcanoes typically of 400km diam, 1.5 km high
* Evidence of explosive vulcanism in the past
* Wind erosion patterns
* Faults and fractures
* Volcanic "pancake" domes up to 7.5 km diam
* Volcanic calderas (craters in the top of a volcanic mountain)
* Multiple impact craters (which would result from a split impactor like Comet Shoemaker Levy 9)
* A double-ring impact basin named Cleopatra similar to some found on the Moon
* Flooded impact craters
* Intensely deformed terrain
* Smooth halos formed by the bow shock of the atmosphere as projectiles plunge into the planet
* Possible sedimentary deposits.

The youth of the surface is a puzzle which remains to be solved. The age of the surface is only about 500 million years. This is about twice as old as Earth's average surface age, but much younger than the Moon's. There doesn't seem to be any continuous resurfacing such as that found on Jupiter's moon, Io. There may have been a catastrophic resurfacing which occurred as a one-off event. Or Venus may undergo some cyclic process where heat in the core builds up, breaks through into lava flows, and then returns to a dormant state. Whatever processes are at work, the planet has been relatively quiet for the last 500m years. There are no plate tectonics working here. (Plate tectonics is the mechanism which causes "continental drift" on Earth and pushes up our highest mountain ranges.) Venus has a thick, one-plate shell, with a surface crust of basalt. The planet is not cool enough for rigid plates to form. It is thought that the crust is somewhat pliable. It gives and bends rather than breaking up into separate plates, because of its high internal and surface heat. Certain features apparent on the surface of Venus remind me of wrinkles on the cooling skin of marmalade.
Studies of Venus's surface have been undertaken by various methods designed to overcome the fact that we cannot see through the clouds which shroud it so effectively.... ence.

A TALE FROM VENUS

Saturn may have rings, but did you know that Venus has a tail? First discovered in the late 1970's by Pioneer Venus Orbiter, the tail of charged particles was discovered 70,000 km from the planet. Recent findings from the SOHO solar probe reveal that the tail extends almost to Earth's orbit - some 45 million kilometres (see diagram).

The Earth does not have a similar tail because of its magnetic field which protects our atmosphere from the solar wind. In the case of Venus, the solar wind strips particles from the upper atmosphere and scatters them in a similar way to the formation of a comet tail.

By Lesa Moore, Senior Guide, Koolang Observatory, and reproduced by permission.
http://www.asnsw.com/universe/1998/btbv-12980199.htm

THE MOON HAS A COMET-LIKE COMA AND TAIL. Michael Mendillo of Boston University, reporting at this week's meeting of American Geophysical Union in Baltimore, showed that the moon has a tail, consisting of sodium gas, extending at least 15,000 miles away from the lunar surface. The sodium, Mendillo believes, is released from lunar rocks by meteorite impacts and is later dissipated into space where it is formed into a tail by the force of solar radiation..
Lesa Moore

http://newton.ex.ac.uk/aip/physnews.36.html
Physics News 36, May 31, 1991
PHYSICS NEWS UPDATE A digest of physics news items prepared by Phillip F. Schewe, AIP Public Information Number 36 May 31, 1991

PHASES OF THE MOON FOR 2004 (WA TIME)

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	Jan 15 12:46
Jan 22 05:05	Jan 29 14:03	Feb 6 16:47	Feb 13 21:40
Feb 20 17:18	Feb 28 11:24	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	**Apr 5 19:03**	**Apr 12 11:46**
Apr 19 21:21	**Apr 28 01:32**	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hpc5mn03.htm

M

Perth Observatory Volunteers Group

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

Jun 14; Jul 12; Aug 9

PERTH OBSERVATORY STAFF

Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Rick Tanello	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
Marc Appelhof	Maintenance Person/Cleaner

POVG VOLUNTEERS

Mike Freeman	Chairperson
Elaine Walker	Vice Chairperson
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator (contact: ngc2070@bigpond.com)
Jeff Alcroft	Editor (contact: callides@iinet.net.au) or through newsgroup

OBSERVATORY'S VOLUNTEERS ACTIVE MEMBER LIST

Jeff Alcroft	Giuseppe Coletti	Bert Hollebon	Lloyd Robinson
Dick Alderson	David Emrich	Karen Kotze	Sascha Schediwy
Jeanne Bell	Keith Ford	Erin Lalor	Val Semmler
Trevor Beardsmore	Marcel Fortsch	Vic Levis	Vera Smith
Lyall Bell	Mike Freeman	Rob Loney	Patricia Turner
Frank Bilki	Lynda Frewer	Andrew MacNaughtan	Elaine Walker
Tony Beston	Bevan Harris	Len Martin	Sandra Walker
Ric Boelen	Don Hartley	Jacquie Milner	Matthew Zengerer
Eve Cowlishaw	Mark Haslam	John Morris	

HAVE YOU JOINED THE VOLLIE NEWSGROUP YET?

If you've got any news, information or pics post them on the newsgroup.
To join simply send your email address to Bevan Harris at:
ngc2070@bigpond.com

To unsubscribe send an email to:
perthobsvollies-unsubscribe@yahoogroups.com.au

To modify your subscription, visit the group website at:
http//au.groups.yahoo.com/mygroups

June 2004

VollieNews

NEWSLETTER OF THE POVG-THE PERTH OBSERVATORY VOLUNTEERS' GROUP INC.

Venus transit bogs down servers

An unprecedented load on internet servers from people wanting to watch webcasts of the transit of Venus yesterday caught web managers unawares, some having to bring on board new supercomputers to deal with the load.

Three webcasts, one from CSIRO in Canberra, one from James Cook University in Townsville and another from Perth Observatory, all saw unexpected levels of interest.

According to CSIRO there were 1.9 million hits on its webcast website, which was hosted by Telstra, and it streamed live video to just under 50,000 people.

"This is the most watched video-streaming event ever in Australia," CSIRO's Darren Osborne told ABC Science Online.

Perth Observatory tried to spread the load by sending half their images to a supercomputer elsewhere but even that was not enough.

"We had to transfer to another server because we were crashing our ISP," observatory spokesperson Peter Birch told ABC Science Online. "It just took off. I didn't expect anything like we got.

"This was unprecendented."

Simon Dixon network administrator of the observatory's ISP, Highway 1, said the event put "a bit of load" on the system because it was unexpected.

"I didn't know about it until the server was under load," he told ABC Science Online.

He estimated there had probably been between one and a few million hits on the Perth Observatory site and he would prefer to be warned before something like this happened again.

Birch agreed: "In the future thought I think I would have a long discussion with the ISP first," he said. "I don't think they would have believed a transit of Venus would have generated millions of hits."

Not a new problem

The problem of webcasts overloading servers is not new. White cited the case of one webcast of a solar eclipse he was involved in during the late 1990s.

"I know that afternoon we stuffed up the university server. It was over 97% of its capacity for three hours," he said. "I got a funny letter from the web manager the next day saying 'Don't ever do that again'. He had his tongue in his cheek but I think he was very, very surprised at how successful it was"

White said problems were also evident during the 2002 total solar eclipse.

"The world was bristling with webcasts but I couldn't get on to any," he said. "I sat there for an hour trying to find just one site.

"I know the technology is good. I know people are interested. The real problem is that the web is just not big enough and fast enough to do the job."

Osborne said as internet capacity increased, so had demand.

"In 1995 it was not uncommon to expect a simple page to take a minute to download," he said. "Nowadays we expect full video and motion.

"It raises some interesting questions about webcasting," he said. "How do you do it and still satisfy everyone? It's not like TV where it doesn't matter if there's one or one million people watching."

As for the show itself, it seems clouds obscured some of the transit for those viewing webcasts from Perth and Canberra.

"We had a huge band of cloud move in just before the transit began," said Osborne. But things turned out in the end.

"Just before sunset a gap in the clouds appeared and for the next 15 minutes we watched the sunset with Venus in front of it." Cloud also meant that Perth got "about half" the event.

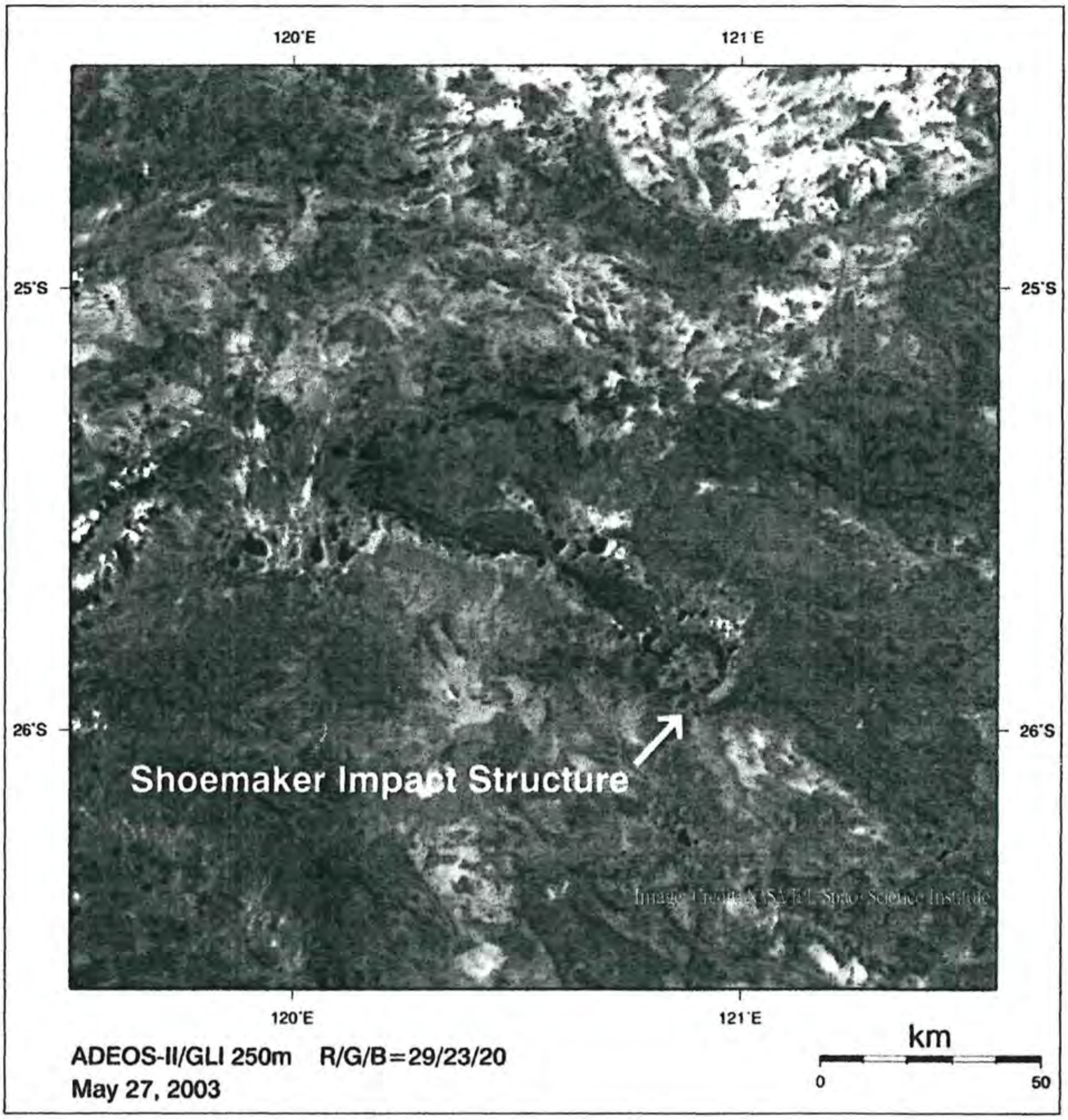
No cloud at all from Townsville, though:

"It was absolutely perfect," said White.

Osborne said it was unclear whether anyone has seen the "black drop" effect, in which the shape of Venus appears to distort as it leaves the face of the Sun. He said some theories suggested this could be because optics had improved since the last time the transit was observed 122 years ago.

Anna Salleh. ABC Science Online 9/06/04

Shoemaker Impact Structure Field Trip



The Shoemaker Impact Structure is named in honour of Gene Shoemaker, and was previously referred to as the Teague Ring. Gene was about to start cooperative work with Geological Survey of Western Australia (GSWA) scientists on the structure in 1997, when he was tragically killed in a car accident in northern Australia. The GSWA recently published a Report on the geology, geochemistry and geophysics of the structure (Pirajno, 2002). Study of the structure also forms part of an ASEG-RF funded PhD project at the University of Western Australia.

Shoemaker is located on the southern margin of the Paleoproterozoic Earaheedy Basin, 110 kilometres to the northwest of the township of Wiluna. Shatter cones and shocked quartz grains confirm that the structure is the result of a meteorite impact. The precise age of the impact is not known, but preliminary radiometric age dating suggests that it occurred sometime between 1000 and 600 Ma. The structure is 30 km in diameter and consists of a collar of upturned sedimentary rocks of the Earaheedy Group surrounding a core of centrally uplifted Archaean basement. The rocks of the central uplift were subjected to post-impact high-temperature hydrothermal alteration, resulting in pervasive alkali metasomatism. The resulting rock of generally syenitic composition is collectively named the Teague Granite. Since its formation, Shoemaker has been eroded to a depth of about 3 km.

The Australian Society of Exploration Geophysicists (ASEG) is acknowledged for permission to publish this article on the CGM website.
http://www.cgm.uwa.edu.au/public/philhawke/preview2002/preview2002.htm

Don't forget to book your place for the Shoemaker Impact Structure Field Trip

Astro News

HUBBLE REVEALS DETAILS IN HEART OF THE TRIFID NEBULA

Three huge intersecting dark lanes of interstellar dust make the Trifid Nebula one of the most recognizable and striking star birth regions in the night sky. The dust, silhouetted against glowing gas and illuminated by starlight, cradles the bright stars at the heart of the Trifid Nebula. This nebula lies within our own Milky Way Galaxy about 9,000 light-years from Earth.

http://spaceflightnow.com/news/n0406/05hubbletrifid/

HUBBLE REFINES DISTANCE TO PLEIADES STAR CLUSTER

Astronomers using NASA's Hubble Space Telescope have helped settle a mystery that has puzzled scientists concerning the exact distance to the famous nearby star cluster known as the Pleiades, or the Seven Sisters.

http://spaceflightnow.com/news/n0406/06hubble/

FAINTEST SURVEY OF DISTANT GALAXIES TAKEN BY HUBBLE

Researchers have measured accurate distances to several faint, red galaxies seen in the Hubble Ultra Deep Field, confirming that three fourths are among the most distant galaxies yet studied.

http://spaceflightnow.com/news/n0406/06distant/

SOURCES OF SOLAR HAZARDS IN INTERPLANETARY SPACE

Life on Earth is nurtured by heat and light from the Sun. Yet life on Earth also is inconvenienced, sometimes potentially threatened, when the Sun sends out huge blasts of energy and high-speed particles. On Earth, our atmosphere and magnetic field help protect us. But in deep outer space, and on the surface of the Moon and Mars, astronauts are vulnerable to solar eruptions.

http://spaceflightnow.com/news/n0406/05solarhazards/

MARS ROVER OPPORTUNITY WILL DRIVE INTO ENDURANCE CRATER

NASA has decided the potential science value gained by sending Opportunity into a martian impact crater likely outweighs the risk of the intrepid explorer not being able to get back out. The soonest Opportunity could enter Endurance is early next week.

http://spaceflightnow.com/mars/mera/040604crater.html

PINWHEEL GALAXY'S HIDDEN WONDERS REVEALED

Like nosy neighbors, astronomers are spying on one of the nearest galaxies to our Milky Way. In studying the Pinwheel Galaxy, also known as Messier 33 (M33), they seek not malicious gossip but new knowledge as they search for clues to how galaxies like our own are born, live and die.

http://spaceflightnow.com/news/n0406/04pinwheel/

CASSINI GETTING EVER CLOSER TO COLORFUL SATURN

As Cassini coasts into the final month of its nearly seven-year trek, the serene majesty of its destination looms ahead. The spacecraft's cameras are functioning beautifully and continue to return stunning views from Cassini's position, 750 million miles) from Earth and now 9.8 million miles from Saturn.

http://spaceflightnow.com/cassini/040603saturncolor.html

PROOF FOUND FOR GAMMA-RAY BURST IN MILKY WAY

Combined data from NASA's Chandra X-ray Observatory and infrared observations with the Palomar 200-inch telescope have uncovered evidence that a gamma-ray burst, one of nature's most catastrophic explosions, occurred in our Galaxy a few thousand years ago. The supernova remnant, W49B, may also be the first remnant of a gamma-ray burst discovered in the Milky Way.

http://spaceflightnow.com/news/n0406/03grbmilkyway/

LOOKING TO CATCH STARS IN THE ACT AS PLANETS FORM

For young stars, the peak age for planet formation is around 1 to 3 million years. By 10 million years old, their resources are exhausted and they retire to a life on the stellar "main sequence." Using telescopes on the ground and in space, a team of astronomers is studying Sun-like stars in their waning formative years. They seek to refine our understanding of planet formation by studying dusty protoplanetary disks around such stars.

http://spaceflightnow.com/news/n0406/03dustdisk/

MONSTER LIES CAMOUFLAGED INSIDE NEBULA'S HEART

Most galaxies, including the Milky Way, are filled with giant clouds of gas and dust called nebulae that appear as dark silhouettes against the starry background. Nebulae shine only when illuminated or excited by nearby energy sources.

http://spaceflightnow.com/news/n0406/02monster/

BOEING TO STUDY NEPTUNE MISSIONS FOR NASA

While Boeing is preparing to deliver a proposal to NASA's Jet Propulsion Laboratory for what could become the nation's first nuclear-fission powered exploration spacecraft, the company also is using its unique space heritage and expertise to propel robotic solar system exploration farther than Jupiter.

http://spaceflightnow.com/news/n0406/02neptune/

GREAT OBSERVATORIES FIND BLACK HOLES, HIDDEN OBJECTS

Astronomers unveiled the deepest images from NASA's new Spitzer Space Telescope Tuesday and announced the detection of distant objects-including several supermassive black holes-that are nearly invisible in even the deepest images from telescopes operating at other wavelengths.

http://spaceflightnow.com/news/n0406/01hidden/

ROBOTIC SERVICING MISSION TO HUBBLE CONSIDERED

NASA is asking for proposals to mount a robotic mission to service the Hubble Space Telescope, the agency announced Tuesday. Earlier this year, NASA Administrator Sean O'Keefe killed plans to launch a final space shuttle servicing mission due to human safety concerns in the wake of Columbia. Read the NASA announcement:

http://spaceflightnow.com/news/n0406/01hubble/

PARALLELOGRAM-SHAPED GALACTIC MEAL SPIED

Peering into the "gut" of the galaxy Centaurus A, NASA's Spitzer Space Telescope has captured in unprecedented detail this massive galaxy's last big meal: a spiral galaxy twisted into a parallelogram-shaped structure of dust.

http://spaceflightnow.com/news/n0406/01parallelogram/

EUROPE'S ROSETTA PROBE OBSERVES COMET LINEAR

ESA's comet-chaser Rosetta, whose 10-year journey to its final target Comet 67P/Churyumov-Gerasimenko started on March 2, is well on its way. The first phase of commissioning is close to completion and Rosetta has successfully performed its first scientific activity - observation of Comet Linear.

http://spaceflightnow.com/news/n0405/30cometlinear/

DOUBLE STARS EMERGE AS HEAVYWEIGHT CHAMPIONS

About 20,000 light-years from Earth, two massive stars grapple with each other like sumo wrestlers locked in combat. Both giants, each weighing in at around 80 times the mass of our Sun, are the heaviest stars ever. They orbit each other every 3.7 days,

'thanks'

A big thanks
to all vollies (and permanent staff)
who have assisted directly and indirectly
with the record number of
Star Viewing Night visitors.

PERTH OBSERVATORY
337 Walnut Road, Bickley WA 6076
http://www.wa.gov.au/perthobs

POVG Minutes

Perth Observatory Volunteer Group Inc.
Minutes of Meeting
May 17th 2004
Meeting Commenced at 7.10

Present. E.Walker. D.Emrich. R.Boelen. R.Tanello. A.Williams. M. Haslam. J.Morris. J.Alcott. P.Birch. J.Milner. G.Lowe. L.Martin. F.Bilki. B.Harris.

Apologies.
L.Bell. J.Bell. M.Freeman. T.Beardsmore. K.Kotze. G.Coletti.

Confirmation of Minutes.
Agreed that they are a true and correct record. Moved J.Milner seconded J.Alcott

Treasurer's Report.
B.Harris tabled the Audited Accounts for the previous year. The funds in the Bank remain unchanged at $210.33. He had received notification from the Taxation Office indicating that we were required to enter a Tax Return. He also needed to obtain sample Signatures from the new Committee.

General Business.
D. Emrich asked where the Group obtained the Volunteer coats from, it was thought that they cost approximately $120.00 each, B.Harris undertook to look up the name of the Supplier. If sufficient numbers were required it might be possible to obtain a discount.

P.Birch reported that the Comets were now visible, Comet Neat was fading, and Comet Linear could be viewed soon after sunset in the S.West climbing higher every night, but regrettably they required Binoculars, and would not become naked eye objects. They could now be viewed on the new Sky Camera, now operating from the roof of the Observatory building, accessed from the Observatory Web Site. The Transit of Venus across the Sun would occur during the afternoon of June 8th this would also be shown on the Sky Camera, weather permitting.

There being no further General Business the meeting closed at 7.44pm
Next Meeting June 14th

A big thanks to all Vollies and Staff for a job well done

Thanks to all vollies (and permanent staff) who have assisted directly and indirectly with the record number of Star Viewing Night visitors. The very successful Mars Viewing Nights were the vehicle to push these up, so it has been a long season for most (except myself!). And I can only promise more night work in the coming season, but at least we'll have about four months break. Also, we are organising a Vollies reward night at the Scitech Planetarium in July, so all who contributed to the Observatory's activities are welcome to come along and enjoy the fun.
Jamie Biggs.

VOLLIE ROUNDUP

REGISTER YOUR DAYS AND HOURS NOW!

In order to assist the Observatory plan its operations for 2004/2005 could all vollies please register their intended number of days and hours per month in the programmes they are currently engaged in (eg Star Viewing Nights .).

Please contact Greg Lowe with this information before 2004/07/01.

HELP WANTED

POVG Assistants Urgently Required
3 excellent positions available

Newspaper article collators

One person (plus deputy) to collect newspaper articles relating to Perth Observatory and other local astronomy/astrophysics activities.

Duties: Scan local newspapers, and the like, for relevant articles. Remove articles from the newspaper. Clearly print source and date on article. Forward articles to Observatory in a timely manner (say at least every two weeks).

Deputy to stand in for short periods when requested. Record and report number of hours the incumbents have spent on the project. These positions are ongoing.

Data analysist

One person to analyse BoM hourly weather data (from 1998) for Perth Observatory (Bickley). Ultimately, they will produce a report with annual averages of wind speed and direction, and relative humidity, as a function of season and time, as well the standard deviation of the quantities.

The successful candidate will probably need familiarity with software such as MS Access and Excel (available at the Observatory), or any other similar software package. It is anticipated that this work should take about 50 hours to complete.

Contact Jamie Biggs for further information or to apply. Applications close 2004/07/01.

Dr James Biggs
Government Astronomer/Director
Perth Observatory
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The Maya and the 2012 transit of Venus

2012: End of the 5th Sun
by Will Hart

Certain aspects of the interlocking Maya calendar system have filtered into public consciousness in the last decade and a half. One of them is the prediction that we will come to the end of a solar-planetary cycle in 2012. But what is this cycle exactly and why is it going to end on the winter solstice of that auspicious year? Is the world going to end as some people are forecasting?

The Maya conceived of time and human history as moving in cycles, small and large. While we use a single calendar to keep track of our annual solar circuit and to mark all of the important days within a year, the Maya used a variety of calendars. The array included a 365-day solar calendar; a 260-day sacred calendar and a Long Count calendar that operated something like an odometer with a zero start date. Unlike the other calendars the Long Count clocked linear time and was programmed to stop after 5,125 years elapsed.

The Long Count was begun at the onset of this current cycle, known as the 5th Sun, in 3114 BC. It will clock the required number of years to complete a full cycle of five suns on December 21, 2012. John Major Jenkins has made the case that this date corresponds to two major alignments, (one between the winter solstice sun and the galactic equator; the other an approximate one between solstice sun and galactic core) and it also completes the Great Zodiac precession cycle of 26,000 years. I am not questioning this thesis however I do wonder if that is all there is to the end of this solar cycle- the 5th Sun?

The Maya began their Long Count on what they referred to as the 'Birth of Venus.' Scholars have never been able to determine what the Maya were referring to and neither have alternative researchers. Nevertheless their sacred calendar, the Tzolkin, placed the synodic cycles of Venus in a central role. The 104-year 'Venus Round' cycle (2 Calendar Rounds of 52 years each), was a very important ceremonial event as this was the point in time when the solar and sacred calendars realigned with the cycle of Venus.

I need to insert an important numerical progression at this point to provide a basis for the rest of the article. The number thirteen was a root number for the Maya. It is both a prime number and the eighth number in the crucial Fibonacci series that is one source of the Golden Ratio, 1.618.

If we use 13 as the root of the Mayan calendar system we find the following sequence: 13, 26, 39, 52, 65, 78, 91 and 104, which are achieved by simply adding 13 to each succeeding sum. These are the key numbers in the Mayan calendrics and they have a solid scientific footing. Venus was the central component of the Mayan cosmology. It is for good reason that our nearest planetary neighbor is called earth's sister planet. They have a phase-locked orbital cycle that is based on a 13:8 ratio. That is derived from the fact that Venus revolves around the sun 1.6 times faster than Earth so that 13 Venus revolutions is equal to 8 years. Why is this important? By establishing Venus as the key component of the sacred calendar they automatically built the Golden Ratio (1.6) into the system since that ratio defines the difference between the two planets orbital cycles. By using 13 as the root number they also included the crucial multiples, or powers, of thirteen - 13,000 and 26,000 - or half as well as the full number of years in the precession. We see that the 5 Suns, each lasting 5,125 years, also add up to the Great Zodiacal Year.

We can break these numbers down in different ways and each will show that there was nothing arbitrary about the Mayan system. We somewhat arrogantly disdain other cultures for being superstitious until we come to the number 13 and our own irrationality surfaces. But let's examine how deeply embedded this number - as well as 26, 52 and 91 - are in our own calendar. Our year is divided into four seasons that are demarcated by the equinoxes and solstices.

Each of the four seasons is 91 days or 13 weeks long, which gives us a year of 52 weeks. We see the key Maya 13-base numerical progression reflected in our own calendar. Half of a year is 26 weeks. It is beyond the scope of this article to delve into all of the intricacies of the Mayan calendrical and mathematical systems; they were extremely adept in these fields.

What I have uncovered during my decades of research into this topic are two crucial keys to understanding the system: the 'Transit of Venus' and solar output cycles. It just so happens that the 2012 end date corresponds to a Venus Transit cycle that occurs twice in the next 10 years in 2004 and then in 2012. As mentioned above Venus was central to the Mayan cosmology. The Long Count began on what the Maya call the "Birth of Venus" so it is perhaps not too surprising that it ends on a Transit of Venus.

My research has revealed that a Transit of Venus occurred in 1518 and 1526. This was the period when Cortez landed on the shores of the Yucatan and wound up conquering the Aztec empire. The next transit was in 1631-'39. It was followed by a complete stoppage of the sunspot cycle, which lasted for 70 years (science has no explanation for this event). The 'little ice age' occurred between 1645 and 1720. What do we find associated with the next transit in 1761-'69? We discover the birth of the American Revolution.

There is no doubt that the Transit of Venus was an important divinatory alignment factored into the Maya calendar. We will not have to wait for long to test this theory and also get a glimpse of 2012 during the 'passage' years. But in reality as Jose Arguelles and others have pointed out the precursor years began in 1987 and the final stages of this cycle really kicked into gear in 1991-'1993. How do we know? There has been a tremendous surge in the number and magnitude of natural disasters and this was also forecast as a harbinger of the 5th Sun's demise.

13,000 years is a very important time period since we know that the last ice age ended then. This indicates that there is a periodicity to the solar output cycle. There are short and long term fluctuations in solar output and as a result great ice ages, little ice ages and warm interglacials, which we are in nearing the end of now.

The cyclical nature of the long range weather patterns are well established is are the variable nature of solar activity. We know that that is true since we have been in a 'global warming' period for the past 300 years. The "little ice age" started to thaw in the early 1700s when the sunspot cycle returned. Thelevel of solar activity has been increasing steadily from that 'zero sunspot point' right up to our recent sunspot cycles in 1989-'90 and the double peak in 2000-'02.

(cont.) Is it a coincidence that 2012 also coincides with the next solar sunspot maximum? The actual peak of this 300-year cycle of increasing solar output occurred in 1960 when the number of sunspots exceeded 200, the usual peak is around 100-150. Now, what is interesting is that during the first half of the 20th century the Earth's seismic and volcanic activity were comparatively quiet.

Then after 1960 the level of seismic and volcanic activity increases steadily to the point that the 1990s can accurately be called the 'decade of disasters'. The surge in major earthquakes and volcanic eruptions radically departed from earlier decades. According to the chief scientist for the world's largest reinsurance company Zurich Re, "since 1960 natural disasters are a growth industry."

I hardly need to mention "global warming" since it is constantly in the headlines. However, the truth is obvious for those that care to see it. The Earth has been warming for 13,000 years with periodic short-term cold spells. However, solar output is the forcing mechanism behind global warming and the 5th Sun is intimately tied to that phenomenon. What does the end of the 5th Sun really mean?

I take it very literally to mean that the sun's output is going to change. We are going to enter the flip side of a new 13,000 year cycle. The earth is overheated and so is the sun, the result being planetary instability manifested in rising earthquakes, volcanic eruptions and erratic weather patterns.

These will increase further starting in 2004. The volcanic ash will create more and more cloud cover and that will begin to cool the planet down. If my theory is correct the Maya knew that the Venus Transit acted like a circuit breaker switching off the sunspot cycle and impacting the Sun-Moon-Earth-Venus system. This appears to have happened just prior to the previous two 'little ice ages' that were preceded by what solar physicists call the Spoorer (1400-1510) and Maunder Minimum(s) 1640-1710), periods of radically diminished solar activity.

The Venus Transit will trigger the demise of the 5th Sun and set the stage for the next cycle, the 6th Sun. That is the physical side of the Maya 5th Sun forecast. Unlike many predictions this one is built into the Maya calendar and it can be verified with some historical research. Is the world going to end in a violent crescendo of natural disasters and impacts from cosmic objects? I do not think that is likely nor is it what the Maya predicted.

However, a prolonged period of change is on the horizon that will be ushered in by the 2004 – 2012 'passage'. It will culminate in the galactic alignment and complete the precessional cycle at that point.

References
The Rise and Fall of Maya Civilization, Thompson J. Eric
The How and Why of Maya End Date in 2012 A.D. Jenkins J.M. 1994 (article)
2004-2012 Transits of Venus, Espenak, F. (NASA article)
Abrupt Climate Change: Should we be worried? Gagosian, R.
Little Ice Age a Global Event, Dalziel, D.
http://www.diagnosis2012.co.uk/5thsun.htm

PHASES OF THE MOON FOR 2004

New Moon	First Quarter	Full Moon	Last Quarter
		Jan 7 23:40	Jan 15 12:46
Jan 22 05:05	Jan 29 14:03	Feb 6 16:47	Feb 13 21:40
Feb 20 17:18	Feb 28 11:24	Mar 7 07:14	Mar 14 05:01
Mar 21 06:41	Mar 29 07:48	**Apr 5 19:03**	**Apr 12 11:46**
Apr 19 21:21	**Apr 28 01:32**	May 5 04:33	May 11 19:04
May 19 12:52	May 27 15:57	Jun 3 12:19	Jun 10 04:02
Jun 18 04:27	Jun 26 03:08	Jul 2 19:09	Jul 9 15:33
Jul 17 19:24	Jul 25 11:37	Aug 1 02:05	Aug 8 06:01
Aug 16 09:24	Aug 23 18:12	Aug 30 10:22	Sep 6 23:10
Sep 14 22:29	Sep 21 23:53	Sep 28 21:09	Oct 6 18:12
Oct 14 10:48	Oct 21 05:59	Oct 28 11:07	Nov 5 13:53
Nov 12 22:27	Nov 19 13:50	Nov 27 04:07	Dec 5 08:53
Dec 12 09:29	Dec 19 00:40	Dec 26 23:06	

http://www.wa.gov.au/perthobs/hpc5mn03.htm

(cont.) nearly touching as they spin on the celestial stage.
http://spaceflightnow.com/news/n0405/29doublestars/

MOON TELLS OF UNEXPECTED EARTH CLIMATE CHANGES

Scientists who monitor Earth's reflectance by measuring the moon's "earthshine" have observed unexpectedly large climate fluctuations during the past two decades.
http://spaceflightnow.com/news/n0405/28earthshine/

RAW INGREDIENTS FOR LIFE FOUND AROUND YOUNG STARS

NASA has announced new findings from the Spitzer Space Telescope, including the discovery of significant amounts of icy organic materials sprinkled throughout several "planetary construction zones," or dusty planet-forming discs, which circle infant stars.
http://spaceflightnow.com/news/n0405/27spitzer/

CASSINI SPACECRAFT EXECUTES CRUCIAL ROCKET FIRING

For the first time in nearly five years, the Cassini spacecraft's main engine system ignited Thursday evening for a critical course adjustment that will serve as a dress rehearsal of sorts for Saturn orbit insertion July 1.
http://spaceflightnow.com/cassini/040527burn.html

PROPOSED NUCLEAR-POWERED JUPITER MISSION DEFINED

NASA has issued its mission design requirements to three industry teams for a proposed mission to Jupiter. The Jupiter Icy Moons Orbiter is a spacecraft with an ambitious proposed mission that would orbit three planet-sized moons of Jupiter -- Callisto, Ganymede and Europa -- that may harbor vast oceans beneath their icy surfaces. The mission would be powered by a nuclear reactor and launched sometime in the next decade.
http://spaceflightnow.com/news/n0405/27jimo/

Perth Observatory Volunteers' Group

2004 Volunteer Training & Meeting nights

Training is important for our volunteers, they enjoy it and we need to support these staff members in return for the assistance they render.

Generally, these training nights are scheduled for 7pm the Monday after the week of Last Quarter.

This list is also displayed on the volunteer noticeboard.

Your cooperation is appreciated. Jamie Biggs. Govt Astronomer

July 12th & August 9th

	PERTH OBSERVATORY STAFF
Dr Jamie Biggs	Director and Govt Astronomer
Peter Birch	Astronomer
Ralph Martin	Astronomer
Dr Andrew Williams	Astronomer
Rick Tanello	Astronomer Assistant
Greg Lowe	Astronomer Assistant
Janet Bell	Administration Officer
Di Johns	Clerical Officer
Arie Verveer	Technical manager
John Pearce	Mechanical technician
Marc Appelhof	Maintenance Person/Cleaner

	POVG VOLUNTEERS
Mike Freeman	Chairperson
Elaine Walker	Vice Chairperson
John Morris	Secretary
Bevan Harris	Treasurer and newsgroup moderator (contact: ngc2070@bigpond.com)
Jeff Alcroft	Editor (contact: callides@iinet.net.au) or through newsgroup

Observatory's Volunteers' Active Member List

Jeff Alcroft	Giuseppe Coletti	Bert Hollebon	Lloyd Robinson
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Jeanne Bell	Keith Ford	Erin Lalor	Val Semmler
Trevor Beardsmore	Marcel Fortsch	Vic Levis	Vera Smith
Lyall Bell	Mike Freeman	Rob Loney	Patricia Turner
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Tony Beston	Bevan Harris	Len Martin	Sandra Walker
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Eve Cowlishaw	Mark Haslam	John Morris	

Have you joined the Vollie Newsgroup yet?

If you've got any news, information or pics post them on the newsgroup.
To join simply send your email address to Bevan Harris at:
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Astronomy & Astrophysics

Letter to the Editor

Probing the atmosphere of the bulge G5III star OGLE-2002-BUL-069 by analysis of microlensed Hα line*

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Abstract. We discuss high-resolution, time-resolved spectra of the caustic exit of the binary microlensing event OGLE 2002-BLG-069 obtained with UVES on the VLT. The source star is a G5III giant in the Galactic Bulge. During such events, the source star is highly magnified, and a strong differential magnification around the caustic resolves its surface. Using an appropriate model stellar atmosphere generated by the PHOENIX v2.6 code we obtain a model light curve for the caustic exit and compare it with a dense set of photometric observations obtained by the PLANET microlensing follow up network. We further compare predicted variations in the Hα equivalent width with those measured from our spectra. While the model and observations agree in the gross features, there are discrepancies suggesting shortcomings in the model, particularly for the Hα line core, where we have detected amplified emission from the stellar chromosphere after the source star's trailing limb exited the caustic. This achievement became possible by the provision of the very efficient OGLE-III Early Warning System, a network of small telescopes capable of nearly-continuous round-the-clock photometric monitoring, on-line data reduction, daily near-real-time modelling in order to predict caustic crossing parameters, and a fast and efficient response of a 8 m class telescope to a "Target-of-Opportunity" observation request.

Key words. techniques: gravitational microlensing – techniques: high resolution spectra – techniques: high angular resolution – stars: atmosphere models – stars: individual: OGLE 2002-BLG-069

1. Introduction

Near extended caustics produced by binary (or multiple) lenses, the source star undergoes a large total magnification in brightness. Furthermore, its surface is differentially magnified because of a strong gradient in magnification. The relative lens-source proper motion is typically slow enough to allow the light curve to be frequently sampled. This translates to a high spatial resolution on the source star's surface and hence permits its radial brightness profile to be inferred from the observations. Over the past four years, coefficients characterizing linear or square-root limb-darkening profiles have been obtained with the microlensing technique for several Bulge

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* Based on observations made at ESO, 69.D-0261(A), 269.D-5042(A), 169.C-0510(A).

giants and sub-giants (Fields et al. 2003 and references therein) and a main sequence star (Abe et al. 2003). A new generation of stellar atmosphere models (Orosz & Hauschildt 2000) have revealed limb-darkening laws that are significantly different from the traditional analytic ones (Bryce et al. 2002; Claret & Hauschildt 2003). The centre to limb variation of spectral lines can show markedly different behaviour from that of the continuum. Most moderately strong and weak lines weaken towards the limb, but resonant scattering lines can vary in a much more pronounced way (Loeb & Sasselov 1995). In cool giants, $H\beta$, being formed lower in the atmosphere, is more limb-darkened than $H\alpha$. TiO and Ca II show strong variations, and some lines and bands may even be limb-brightened. Intensive spectroscopic monitoring of a caustic exit at high resolution with high *S/N* should reveal temporal variations in the equivalent widths of promising spectral lines that can be compared with predictions from stellar atmosphere models (Heyrovský et al. 2000).

We present here the first photometric and spectroscopic monitoring campaign that has successfully been performed at high resolution with dense sampling. Previously, Castro et al. (2001) obtained two KECK HIRES spectra of EROS 2000-BLG-5, but missed the trailing limb of the caustic where the effects are stronger, while the data in the qualitative analysis of Albrow et al. (2001) involved dense coverage but at low resolution. Afonso et al. (2001) provided a model that reproduces the photometric data and found an excess of $H\alpha$ at the limb. They attribute the excess to chromospheric emission, but it could be due to shortcomings of the synthetic spectra. Using a determination of the spectral type of the source star, we have computed the limb-darkening profiles in R and I from appropriate PHOENIX synthetic spectra of the source star and fitted a fold-caustic model to our photometric data obtained during the caustic exit. This model has been used here to compute the synthetic spectrum for wavelengths around the $H\alpha$-line. A more detailed report on the determination of the stellar parameters and the analysis of other spectral lines will be presented elsewhere (Beaulieu et al. 2004), as will the details of a full binary lens model fit to the PLANET observations of the event (Kubas et al. 2004).

2. OGLE 2002-BLG-069 photometry and spectroscopy

The PLANET collaboration, comprising six different telescopes, namely, SAAO 1.0 m (South Africa), Danish 1.54 m (Chile), ESO 2.2 m (Chile), Canopus 1.0 m (Australia), Mt. Stromlo 50 in (Australia) and Perth 0.6 m (Australia), commenced photometric observations of OGLE 2002-BLG-069 alerted by the OGLE-III early Warning System (Udalski 2003) in early June, 2002. From online data reductions on 25 June it was realised that the event involved a binary lens and a bright giant source star. With the source taking $\sim$1.4 days to cross the caustic on entry, it appeared to be an excellent candidate for time-resolved spectroscopy of the caustic exit. Using the predictions based on modeling our photometry, and thanks to excellent coordination with the staff at La Silla and Paranal, very good coverage was obtained during the caustic exit together with post-caustic reference spectra. These observations were performed using the UVES spectrograph mounted on Kueyen (VLT UT2) as part of Target-of-Opportunity and Director's Discretionary time. Thirty-nine spectra with exposure time of 20 min (1 h for the post caustic observations) were obtained alternately in the so-called standard settings, 580 and 860, covering the full 4800–10 600 Å range at a resolution of 30 000 with *S/N* ranging from 50 to 130. From an analysis of the curve-of-growth of 100 Fe I and Fe II lines as done by Minniti et al. (2002), and independently from the study of the Ca II and Mg lines (Jørgensen et al. 1992), a good fit to all the data was obtained with a plane-parallel model atmosphere having $T_{\rm eff}$ = 5000 K, $\log(g) = 2.5$, $v_{\rm turb} = 1.5$ km s^{-1} and [Fe/H] = -0.6. The calibration of the MK spectral type gives, for a G5III star, $T_{\rm eff}$ = 5050 K, $M_V = +0.9$, $(V-I) = 0.95$, $M/M_\odot = 1.1$ and $R/R_\odot = 10$. At HJD = 2 452 455.2754, the source was amplified by 17.7. The measured color from SAAO data are $I = 13.01 \pm 0.01$, $(V-I) = 2.06 \pm 0.02$, so $E(V-I) = 1.11 \pm 0.02$. We adopt a conservative $A_V/E(V-I) = 2.2 \pm 0.3$, and then derive a distance of 9.4 ± 1.4 kpc.

3. Modeling of the caustic exit

With ρ denoting the fractional radius of the source star, we approximate its wavelength-dependent brightness profile $I^\lambda(\rho) = \bar{I}\xi^\lambda(\rho)$ by concentric rings of constant intensity. A model atmosphere for the stellar parameters given in the previous section was computed with the PHOENIX grid v2.6 (based on the code described by Allard et al. (2001) but using spherical geometry and spherically symmetric radiative transfer). A synthetic spectrum was calculated from this model at a spectral resolution of 0.05 Å at 128 steps in source radius. The intensity profile was interpolated with cubic splines at 1000 points equally spaced in $\cos\vartheta = \sqrt{(1-\rho^2)}$ where ϑ is the emergent angle, so that the width of the rings of constant intensity decreases toward the stellar limb. For a broadband filter (s), the intensity profile $\xi^{(s)}(\rho)$ is obtained by convolving the source brightness profile with the filter, CCD transmission and atmosphere response functions. The observed magnitude $m^{(s)}(t)$ reads $m^{(s)}(t) = m_{\rm S}^{(s)} - 2.5\lg\left\{A^{(s)}(t) + g^{(s)}\right\}$ where $m_{\rm S}^{(s)}$ is the intrinsic source magnitude, $g^{(s)} = F_{\rm B}^{(s)}/F_{\rm S}^{(s)}$ is the ratio between background flux $F_{\rm B}^{(s)}$ and intrinsic source flux $F_{\rm S}^{(s)}$, and $A^{(s)}(t)$ the source magnification at time t.

The photometric data presented in the lower panel of Fig. 1 show a peak with the characteristic shape resulting from a fold-caustic exit. For a source in the vicinity of a fold caustic, the magnification $A^{(s)}(t)$ can be decomposed (e.g., Albrow et al. 1999a) as $A^{(s)}(t) = A_{\rm crit}^{(s)}(t) + A_{\rm other}(t)$, where $A_{\rm crit}^{(s)}(t)$ denotes the magnification of the critical images associated with the caustic, and $A_{\rm other}(t)$ denotes the magnification of the remaining images of the source under the action of the binary lens.

Let us consider a uniformly moving source crossing the caustic within $2\,\Delta t$ and exiting the caustic by its trailing limb at $t_{\rm f}$. If one neglects the curvature of the caustic and the variation of its strength over the size of the source, the magnification of the critical images reads $A_{\rm crit}^{(s)}(t) = a_{\rm crit}\,G_{\rm f}\left(-\frac{t-t_{\rm f}}{\Delta t}\,;\,\xi^{(s)}\right)$

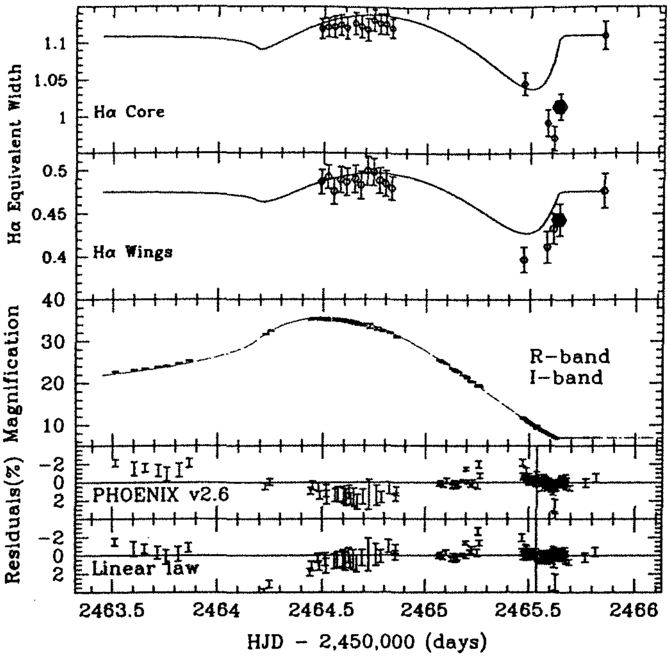

Fig. 1. Equivalent-width variation of the Hα core (*top panel*) and wings (second panel from the top); the open circles in the plots of the equivalent-width variation correspond to our UVES data, while the adjoining solid lines represent the model predictions over the course of the caustic passage. The big dots correspond to the spectra of 10 July, UT 02h58. *Third panel:* model light curves and photometric data, where R-band data are plotted in red and I-band data in blue; model residuals from the chosen PHOENIX atmosphere (fourth panel) and from the linear limb-darkening law (*bottom panel*), with the same color convention. The model parameters can be found in Table 1. The majority of model residuals are below the 2% level. The post caustic observations have been plotted at 2465.85, but have been taken on 16 August.

Table 1. Model parameters of a fit to data obtained by PLANET with the SAAO 1.0 m, UTas 1.0 m, and ESO 2.2 m on the microlensing event OGLE 2002-BLG-069. While source magnitudes $m_S^{(s)}$ and blend ratios $g^{(s)}$ result from a fit involving a binary lens model to the complete data sets, the remaining parameters have been determined by applying a generic fold-caustic model with PHOENIX limb darkening solely to the data taken around the caustic exit.

Parameter	Value	Parameter	Value
$m_S^{\text{SAAO}\,[I]}$	16.05	t_f (days)	2465.637
$m_S^{\text{UTas}\,[I]}$	16.05	Δt (days)	0.7297
$m_S^{\text{ESO 2.2 m}\,[R]}$	16.3	a_{crit}	19.60
$g^{\text{SAAO}\,[I]}$	0.16	a_{other}	7.011
$g^{\text{UTas}\,[I]}$	0.064	ω (days)$^{-1}$	−0.04519
$g^{\text{ESO 2.2 m}\,[R]}$	0.0083		

where $G_f(\eta;\xi^{(s)})$ is a characteristic function (Schneider & Wagoner 1987) which solely depends on the intensity profile $\xi^{(s)}$. For $|\omega(t-t_f)| \ll 1$, the magnification of the non-critical images can be approximated by $A_{\text{other}}(t) \simeq a_{\text{other}}\,[1 + \omega(t-t_f)]$ where a_{other} is the magnification at the caustic exit at time t_f and ω measures its variation.

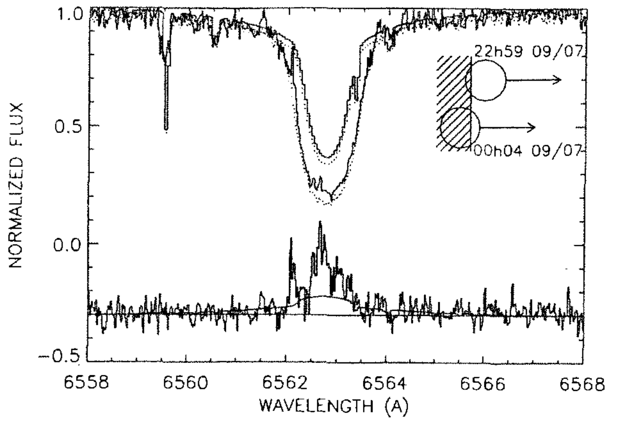

Fig. 2. *Upper panel*: two UVES spectra (two lower curves) corresponding to 9 July, UT 22h59 (HJD – 2 450 000 = 2465.47, solid line) and 9 July at UT 00h04 (reference spectra, HJD–2 450 000 = 2464.51, dotted line), as well as two computed synthetic spectra at the same epochs (the two upper solid and dotted curves). *Lower panel*: fractional difference $\delta F^\lambda = 2(F^\lambda_{00h04} - F^\lambda_{22h59})/(F^\lambda_{00h04} + F^\lambda_{22h59})$ (lower solid line) for wavelengths in the vicinity of the Hα-line shifted vertically by −0.3. Both the observations and the model are shown. On the upper right, we show the relative position of the source star at each epoch with respect to the fold-caustic shown as dashed.

As the period during which our generic fold-caustic model is believed to be a fair approximation, we choose the range $2463.45 \leq$ HJD–2 450 000 ≤ 2467. Restricting our attention to those data sets with more than two points in this region leaves us with 29 points from SAAO and 15 points from UTas in I as well as 98 points from the ESO 2.2 m in R, amounting to a total of 142 data points. From a binary lens model of the complete data sets (Kubas et al. 2004) for these observatories and filters, we have determined the source magnitudes $m_S^{(s)}$ and the blend ratios $g^{(s)}$. With the adopted synthetic spectra, we compute the stellar intensity profiles for I and R, and use these for obtaining a fit of the generic fold-caustic model to the data in the caustic-crossing region by means of χ^2-minimization, which determined the 5 model parameters t_f, Δt, a_{crit}, a_{other}, and ω as shown in Table 1. If a classical linear limb darkening is included in the list of parameters to fit (as in Albrow et al. 1999b), the best fit is obtained with $\Gamma = 0.5$.

The modeled light curve and the structure of the residuals of the two fits are given in the lower panels of Fig. 1. The fit with adopted PHOENIX limb darkenings clearly show systematic trends at the level of 1–2%. The same trends in the residuals can be seen from the figure, which suggests some specific features lying in the real stellar atmosphere. We checked whether this discrepancy can be caused by the straight fold caustic approximation, but from running the already mentioned global binary lens model neither the very small curvature of the caustic nor the source trajectory can explain this systematic effect.

4. Comparison between synthetic spectra and spectroscopic data

The fold-caustic model derived in Sect. 3 is used to compute the source flux during the caustic exit in order to obtain a