



AUCKLAND
ASTRONOMICAL
SOCIETY

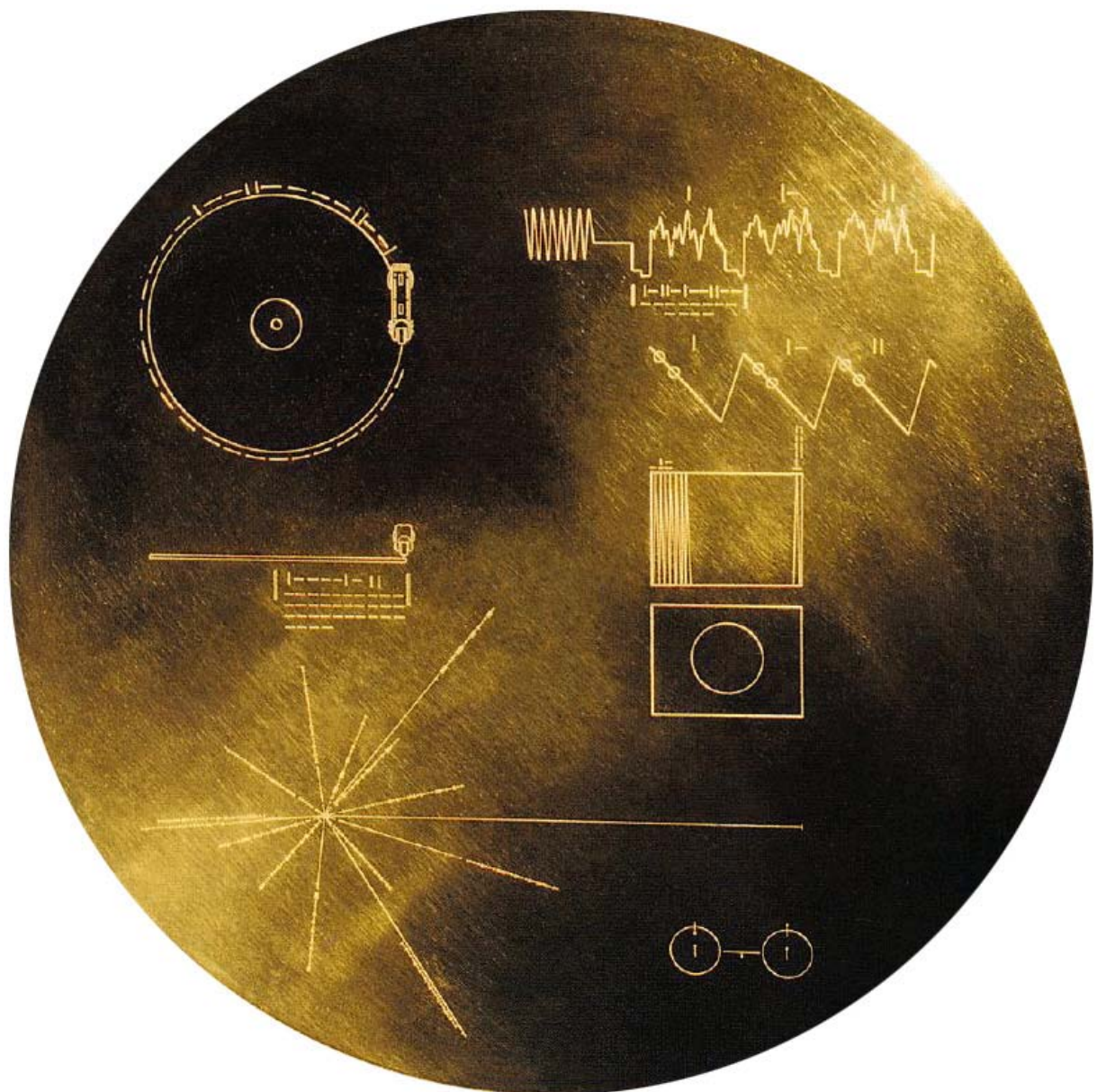
November 2010

SOCIETY JOURNAL

A Message from Earth: The Voyager Golden Record

Society Meeting with Jon Lomborg

Monday 22 November 8:00pm. Note the change of date



Jon Lomborg was Design Director of this legendary project. He devised the portrait of humanity in photographs and diagrams intended for ET's who find either of the two Voyager spacecraft, adrift in space, thousands of millennia hence.

His cover design for the Record should endure for at least a thousand million years. Mr. Lomborg will tell the story of the evolution of the images, music and sounds that represent our species to the Galaxy.

The Burbidge Dinner

Highlights and Prize-winners



Jennie McCormick announcing the winners of the Astrophotography Competition.



Kenric Ma with his son holding the Harry Williams Trophy. Kenric's entry won first place in the Solar System Section and was overall winner of the Astrophotography Competition and the Harry Williams Trophy.



Roger Feasey announcing the winner of the Beaumont Prize for Journalism. The first prize went to Dave Moorhouse for his article entitled "One Computer To Rule Them All", about the computer control setup of the 14-inch telescope at the Kumeu Observatory. Second place went to Gavin Logan for his article on choosing a good refractor.



Dave Moorhouse and Michelle Knowler. Dave was winner of the Beaumont Prize for Journalism and the Deep Sky Section of the Astrophotography Competition.



Dr Bernie Brenner, MC for the Burbidge Dinner



Professor John Hearnshaw, Keynote Speaker for the Burbidge Dinner, talking about his trip to visit observatories and universities in exotic places as part of his job to promote cooperation in Astronomy during the International Year of Astronomy.

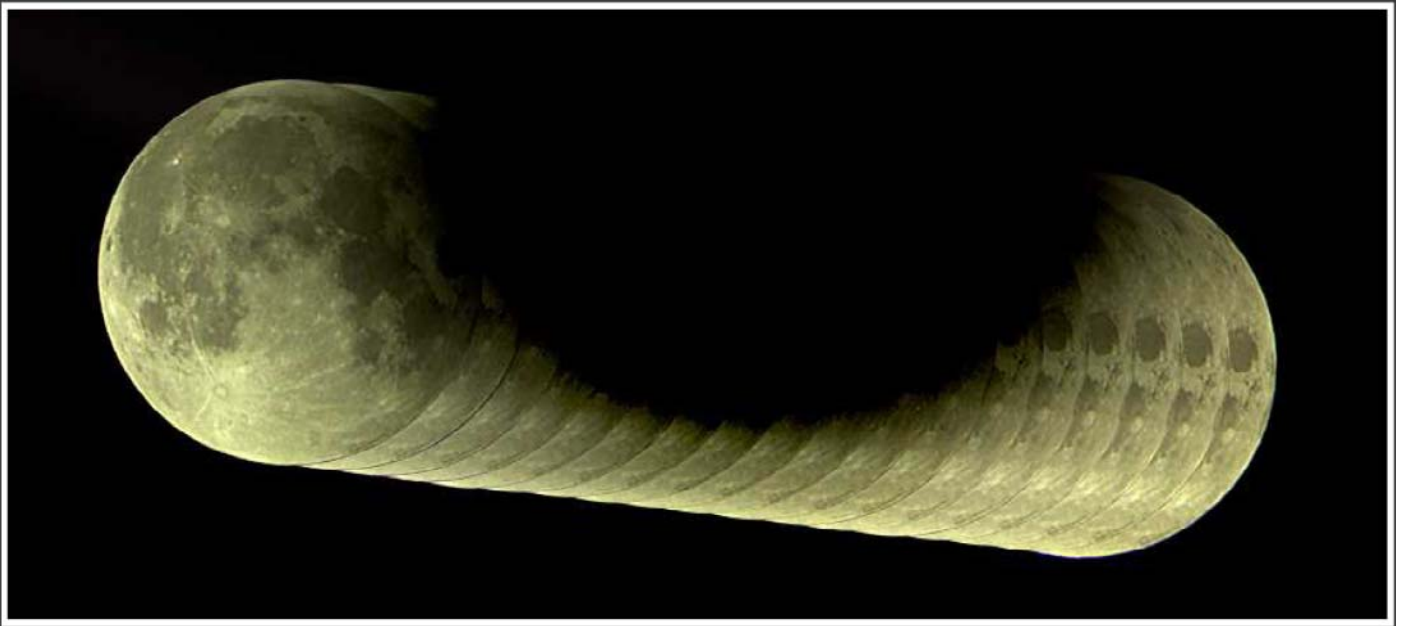


Noel Hendry was the successful bidder for the 8" ASTRONZ Dobsonian Telescope.



Olga Brochner, winner of the Door prize and obviously very happy about it too.

Astrophotography Competition Results



The winning entry for the Harry Williams Trophy and winner of the Solar System Section of the Astrophotography Competition by Kenric Ma of Auckland. Judged by Alan Gilmore and Pam Kilmartin of Mt John Observatory, The University of Canterbury.

Judges' Comments

Solar System first place

We have seen many montages and multiple exposures of lunar eclipses but nothing like this. The picture dramatically shows the

Moon's passage through the Earth's central shadow without any need for further explanation. The series of images has been meticulously exposed, processed and stacked. A stunningly original approach, beautifully executed.

Overall Winner of the Harry Williams Trophy

Given the high level of technical perfection that was evident in so many of the entries, the judges needed other criteria to sift out the truly outstanding picture among the entries. We decided that the overall winner was Partial Lunar Eclipse Earth's Shadow. As earlier stated we thought this a stunningly original approach, beautifully executed.



NGC 3581 by Dave Moorhouse of Auckland. Winner of the Deep Sky Section

Judges' Comments

This is an original choice of target and the picture has great appeal to the eye. Although it is entered as NGC3581, that refers to just one of the brighter knots in the picture. Other bright knots also have NGC designations, showing just how faint the outer extensions of the nebulosity are. Like most other entries in this section the technical details are about as good as one can get: the star colours are natural and the focus and tracking are excellent. The dark nebulae silhouetted on the bright hydrogen emission regions are dramatically captured on what is really a faint background.



Wide Rho I by John Burt of Gisborne. Winner of the Artistic/Miscellaneous Section

Judges' Comments

This is a striking picture with subtle colours in the reflection nebula around Antares and Rho Ophiuchus, and delicate traceries of dust across the Milky Way. It shows superbly detailed dust clouds among the bright Milky Way regions along with densely coloured HII regions at top edge of view. In many ways this picture is a Deep Sky photo but the colours qualify it for artistic as well. It is technically perfect in every detail.

Calendar of Events

November Programme

Mon	1	8:00pm	Practical Astronomy
Fri	5	7:30pm	Young Astronomers with Margaret Arthur. A session in the Planetarium
Mon	8	8:00pm	Introduction to Astronomy with Bernie Brenner Note change of date
Mon	15	8:00pm	Film Night with Gavin Logan
Wed	18	7:30pm	Council Meeting
Mon	22	8:00pm	Society Meeting. The Voyager Golden Record with Jon Lomberg. Note the change of date

Film Night Monday November 15 8:00pm

El Nino and Nuclear Nightmare

Two BBC documentaries.

El Nino tells about how this weather pattern effects climates and lives in many parts of the world. It also tells how it was discovered and how its discovery improved man's knowledge of how the Earth's climate works.

Nuclear Nightmare is a controversial look at how exposure to radiation effects the human body.

This is the last film night for the year.

Practical Astronomy November 1 8:00pm

Introduction to Astrophotography with Dave Moorhouse. A beginner's guide in getting started with astrophotography. Will include what equipment and software are required and what to expect from your images.

The 2010 Council

President	Grant Christie	(021) 024-04992
Vice President	David Britten	(09) 846-3657
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	Shaun Fletcher	(09) 480-5648
Webmaster	Nick Moore	(09) 537-1500
Council	Gavin Logan	(09) 820-6001

December Programme

Fri	3	7:30pm	Young Astronomers.
Mon	6	8:00pm	Practical Astronomy. Summer Star Party
Mon	13	8:00pm	Society Meeting. TBA
Mon	20	8:00pm	Introduction to Astronomy with Bernie Brenner. Note change of date

Note: There will not be a film night in December

Introduction to Astronomy Monday November 8 8:00pm Note the change of Date

Saturn and Neptune with Bernie Brenner.

This is the continuation of the basic course in Astronomy

Young Astronomers Friday Nov 5 at 7:30pm

The young astronomers' evening will feature a Planetarium show. This is always popular and it is not normally available on a Friday.

Everyone is welcome, especially children and parents.

Welcome to New Members

Beverly Coulam (ordinary)	David Archer (family)
Barry Everett (family)	Elizabeth & Graham
Jill Stoker (ordinary)	Rogerson (family)
Mohammed Jada (family)	Andre Bellvue (student)

Society Contacts

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Journal journal@astronomy.org.nz

Website www.astronomy.org.nz

Membership inquiries contact Andrew Buckingham at treasurer@astronomy.org.nz or by phone on (09)-473-5877 or 027-246-2446

October Society Meeting

The 25 Most important Discoveries in Astronomy during the last Century.

With Professor John Hearnshaw. Report by Clive Bolt

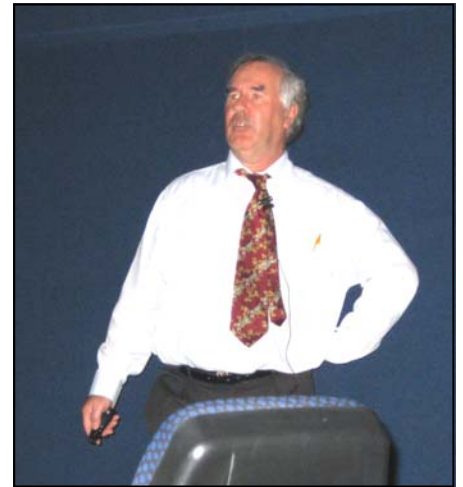
The Space Room was not available and so the meeting was held in the Planetarium. The comfort, projection and sound worked surprisingly well, except that I could not see the speaker in the gloom from the rear of the room.

Any assessment of important discoveries is necessarily limited by selection criterion and John certainly made it clear that he was only including key discoveries that were fully understood during the 20th Century and that he did not include the space probes. He also admitted that colleagues and students offered another 26 discoveries. John has recently published a book of 53 essays on astronomy that includes the 25 discoveries of his talk. His talk explained his reasons for making the choice and gave a much better insight into each discovery. It was interesting to see a comparison of the state of knowledge in 1900 with what was known by the year 2000. The rate of significant discoveries made during the 20th Century tailed off towards the end of the Century while the number of publications in astronomy increased substantially. I can personally identify with the academic pressure that leads to the "publish or perish" mentality

that produces a high proportion of works of sometimes dubious value.

It is interesting to reflect on the reasons for the reduction in the rate of fundamental discoveries. The audience certainly did, considering the questions that were raised. The suggestion is that most fundamental discoveries had already been made by the end of the century, but that needs to be considered keeping the original criterion in mind. There are still many things left to understand and even discover. The nature of dark energy and dark matter are two good examples of phenomena that were known by the end of the century but certainly not understood, not even now.

During questions the Nobel Prize awards were proposed as criteria for selection of importance. John pointed out the inconsistencies in the awarding of the Nobel Prize for discoveries in astronomy. Two fine examples he noted included the discovery of the Cosmic Microwave Background by Penzias and Wilson in 1965 when they actually had no idea what it was. The Nobel Prize should probably have gone to George Gamow and Robert Dickie who predicted its existence in 1946, although they did not quite get the temperature correct. Another was Edwin



Professor John Hearnshaw talking to the Society in the Planetarium.

Hubble for his work in identifying the extragalactic nature of galaxies and the expansion of the Universe. Hubble was never awarded a Nobel prize for his groundbreaking discoveries. Of course we are all familiar with the recent example of the President who got a Nobel Prize for Rhetoric.

Our thanks to you, John, for a most interesting talk. I am privileged to have a copy of John's book, *Cosmic Essays*. This is a lovely coffee-table book of essays on astronomy and John's experiences and contributions to it. Near the back John lists the whole 51 discoveries. I can thoroughly recommend this little

Cosmic Essays

Written by John Hearnshaw

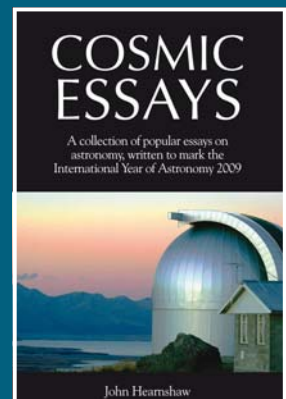
\$25.00 + \$5.00 NZpp

A new book by Prof John Hearnshaw from the University of Canterbury is now for sale. *Cosmic Essays* is a collection of 53 popular essays on astronomy, written to celebrate the 2009 International Year of Astronomy. This would make a great addition to all society libraries and a great Christmas present.

To order your copy

Contact: Prof John Hearnshaw

john.hearnshaw@canterbury.ac.nz



Film shows Human Side of Great Scientists

Report by Gavin Logan

The October Film Night featured British Drama "Einstein and Eddington", a story of an unlikely partnership between two scientists resulting in a new way of looking at the Universe.

Over sixty society members watched a story that unfolded in the backdrop of World War One and showed two scientists, with contrasting beliefs, prove a new theory on gravity.

Arthur Stanley Eddington was a Quaker with a strong belief in God. He was appointed chief astronomer at Cambridge by Sir Oliver Lodge. He was instructed to research Einstein's work but also to defend the Newtonian status quo. Albert Einstein, working in Berlin at the Prussian Academy of Sciences, was a man who could not conceive of a God or existence after death. He was secretly sending his work to Eddington, after Eddington had written to him about irregularities in the orbit of Mercury. Correspondence between the two continued although it was illegal in both Britain and Germany during the war.

Eddington was at odds with people at Cambridge over his attitude to the war and he was abused by angry, xenophobic and anti-pacifist protestors. Einstein was locked out of his work because of his irreverence to the German war effort. Einstein had a failing marriage and a new lover (Elsa), while Eddington lost one of his best friends, William Marston, who went to war as an officer in the Cambridgeshire Regiment and was among the 15,000 killed by the German use of chlorine gas at the Second Battle of Ypres.

Eddington realised he could prove Einstein's prediction that space and light is bent by gravity by observing the solar eclipse of 29th May 1919 on the west African island of Principe. He managed to gain funding for his expedition, despite Lodge's initial opposition. The war ended and he went to Africa, returning with two photographs from the eclipse to compare with photographs of the night sky under normal



German Soldiers prevent Einstein from entering the Prussian Academy of Science because of his anti German behaviour resulting from his abhorrence of the use of science in war. Einstein is played by Andy Serkis and Eddington by David Tennant.

conditions. Eddington compared them in public with Lodge in attendance and not only proved Einstein right but also found this confirmation reaffirmed his faith as he stated, "I can hear God, thinking". News of his vindication reached Einstein, and crowds of press arrived at his door. A year later, in the closing scene, Einstein visited Cambridge and met with Eddington.



Eddington and Einstein finally meet after the war and shake hands at the end of the film.

Next month's Film Night is the last one for 2010 and it is a double feature of BBC documentaries "El Nino" and "Nuclear Nightmare". It is on 8pm Monday 15th November at Stardome Observatory.

El Nino tells about how this weather pattern effects climates and lives in many

parts of the world. It also tells how it was discovered and how its discovery improved mans knowledge of how the Earths climate works.

Nuclear Nightmare is a controversial look at how exposure to radiation affects the human body.

Dorado

A southern constellation well worth investigating

By Ivan Vazey

A little low down in the sky to become part of Greek mythology, Joseph Bayer named this constellation after the Oceanic fish, the Mahi-Mahi. An alternate name for the constellation was Xiphias (or Swordfish) and this name first appeared in Johannes Kepler's 'Rudolphine Tables' that were published in 1627. These tables were important because they contained very accurate positions for naked eye stars visible in the Northern hemisphere around Europe. These came from Tycho Brahe's observations from the island of Ven (Ven in the Oresund Strait), before the invention of the telescope.

Included were tables of planetary motion based on Heliocentrism. (where all planets orbit the Sun) This viewpoint he gained through his knowledge of Copernicus

The second point that he put forward in his 'Rudolphine Tables' was that the orbits of the planets in our solar system were elliptical. He arrived at this conclusion by calculating an orbit for the planet Mars that worked when put to

the test.

Kepler's formulas, combined with the accuracy of Brahe's measurements, were the contributing factor to the overthrow of the Geocentric system that had dominated astronomical thinking for around two thousand years.

Dorado is important to us for containing our neighbouring Galaxy, the Large Magellanic Cloud. The LMC is a transition type galaxy, between a barred spiral and an irregular galaxy. Of interest in this area is always the Tarantula Nebula (NGC 2070) but there are many other objects worth seeking in the LMC

Looking in the LMC

NGC 1850 Dreyer found this. Very bright at and large at 9.3, condensed and resolvable.

NGC 1858 Bright, large and elongated with some nebulosity.

Central Dorado.

NGC 1672 Barred Spiral Galaxy anchoring two other galaxies. NGC 1688 and 1703



NGC 1672 A Barred Spiral Galaxy visible in Dorado. Visible are dark filamentary dust lanes, young clusters of bright blue stars, red emission nebulae of glowing hydrogen gas, a long bright bar of stars across the centre, and a bright active nucleus that likely houses a supermassive black hole. Light takes about 60 million years to reach us from NGC 1672, which spans about 75,000 light years across.

To the NW five visible galaxies are readily found NGC 1566, (a spiral Seyfert) 1596, 1602, 1549 and 1602

And many others.

Library Corner

With Tony Reynolds

Featured Section

– QB54 Extraterrestrial Life

The library has a number of titles concerning the possibility of life beyond Earth.

Titles include;

Intelligent Life in the universe,
by Carl Sagan

To Utopia and Back

by Norman Horowitz

Signs of Life

by Ian Ridpath

User's Guide

–Browsing the Catalogue

The AAS library catalogue is available online using your membership login to the website. It can be accessed at the library using the 'Society' user account on the library PC.

From the Member Menu, find My Library Books and click Browse AAS

Library. From here you can search the library for title or author by entering your search text in the appropriate box. The search will return all entries containing the text. The search is not a keyword search so 'Patrick Moore' and 'Moore, Patrick' will return different results. Keep your searches open (just use Moore) but be prepared for a few extra hits.

Where the book has been catalogued, its location in the library is listed in the column 'Shelf/LOC Code' (LOC stands for Library of Congress – the cataloguing system used by us). If no code is shown in this column then the book has not yet been catalogued and will be a little harder to find.

Feel free to use the 'Society' user account on the library PC and I welcome any feedback to improve the service. Happy hunting.

New Books

Magnificent Mars

By Ken Crowell

A large-format book covering topics such as the planet's surface, missions to the planet, its satellites and signs of life.

QB641

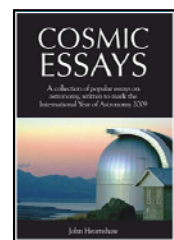


Cosmic Essays

By John Hearnshaw

The library now has a signed copy of John Hearnshaw's latest book.

A collection of 53 popular essays in astronomy, written to celebrate the International Year of Astronomy 2009. QB51



The Night Sky in November

by Alan Gilmore



Jupiter is the evening 'star', appearing north of overhead soon after sunset. Binoculars and small telescopes will show Jupiter's brightest moons on either side of the planet, swapping sides from night to night. Jupiter is around 650 million km away from us now.

From mid November to early December Mercury and Mars are near the southwest horizon at twilight. Mercury is bright and white. Mars is fainter and reddish; similar to nearby Antares, the red-giant star at the Scorpion's heart. (Antares means 'rival to Mars' in Greek.) At the beginning of the month Mars is directly below Antares. Mercury is further below and left. The stars slip downward past the two planets. By the 13th Mars will be to the right of Antares with Mercury just below the pair. Around the 17th Mercury will be between Antares and Mars. Thereafter Mercury will be above Mars as both disappear in the December twilight. The planets' apparent closeness is strictly line of sight. At mid-month Mercury is around 200 million km from us and coming closer, while Mars is 350 million km away on the far side of the Sun. Scorpius has its tail pointed up toward the zenith, like a back to front question mark. The tail is 'the fish-hook of Maui' in Maori star lore.

Canopus, in the southeast, is the second brightest star in the sky. It moves eastward and upward during the night as the stars appear to circle clockwise around the south celestial pole, SCP.

Canopus is 300 lightyears* away. Seen up close it would be 13,000 times

brighter than the Sun.

Sirius rises in the east around dusk. When low in the sky it is shining through a lot of air. The air breaks its white light into colours so Sirius twinkles like a diamond. It is the brightest star both because it is relatively close, nine light years away, and 23 times brighter than the Sun.

Left of Sirius in the late evening is the constellation of Orion, with 'The Pot' at its centre. Rigel, a bluish supergiant star, is directly above the line of three stars; Betelgeuse, a red-giant star, is straight below. Left again is a triangular group around Aldebaran making the upside down face of Taurus the bull. Still further left is the Pleiades or Matariki cluster, also called the Seven Sisters, Subaru and many other names. Six or seven stars are visible to the eye; dozens are seen in binoculars. The Pleiades cluster is 400 light years away and around 70 million years old.

The Milky Way is low in the sky, visible around the horizon from the northwest, through south into the eastern sky. The broadest, brightest part is in Sagittarius, to the right of the Scorpion's sting. The Milky Way is our edgewise view of the galaxy, the pancake of billions of stars of which the Sun is just one. The thick hub of the galaxy, 30,000 light years away, is in Sagittarius.

Low in the south are the Pointers, Beta and Alpha Centauri, and Crux the Southern Cross. In some Maori star lore the bright southern Milky Way makes the canoe of Maui with Crux being the

canoe's anchor hanging off the side. In this picture the Scorpion's tail can be the canoe's prow and the Clouds of Magellan are the sails.

The Clouds of Magellan, (LMC and SMC), high in the in the southern sky, are two small galaxies about 160 000 and 200 000 light years away, respectively. They are easily seen by eye on a dark moonless night. The larger cloud is about 1/20th the mass of the Milky Way galaxy, the smaller cloud 1/30th. That's still billions of stars in each. The globular star cluster 47 Tucanae appears near the SMC but is 'only' 16 000 light years away. Globular clusters are spherical clouds of stars many billions of years old.

Very low in the north is the Andromeda Galaxy, easily seen in binoculars on a dark night and faintly visible to the eye. It appears as a spindle of light. It is similar in shape to our galaxy but a little bigger and nearly three million light years away.

Venus, the former brilliant evening star, has passed us by. It is now in the morning sky, rising in the southeast dawn twilight. It appears as a tall thin crescent in a telescope: about 50 million km away.

*A light year (l.y.) is the distance that light travels in one year: nearly 10 million million km. Sunlight takes eight minutes to get here; moonlight about one second. Sunlight reaches Neptune, the outermost major planet, in four hours. It takes sunlight four years to reach the nearest star, Alpha Centauri.

Notes by Alan Gilmore, University of Canterbury's Mt John Observatory, P.O. Box 56, Lake Tekapo 7945, New Zealand.

www.canterbury.ac.nz

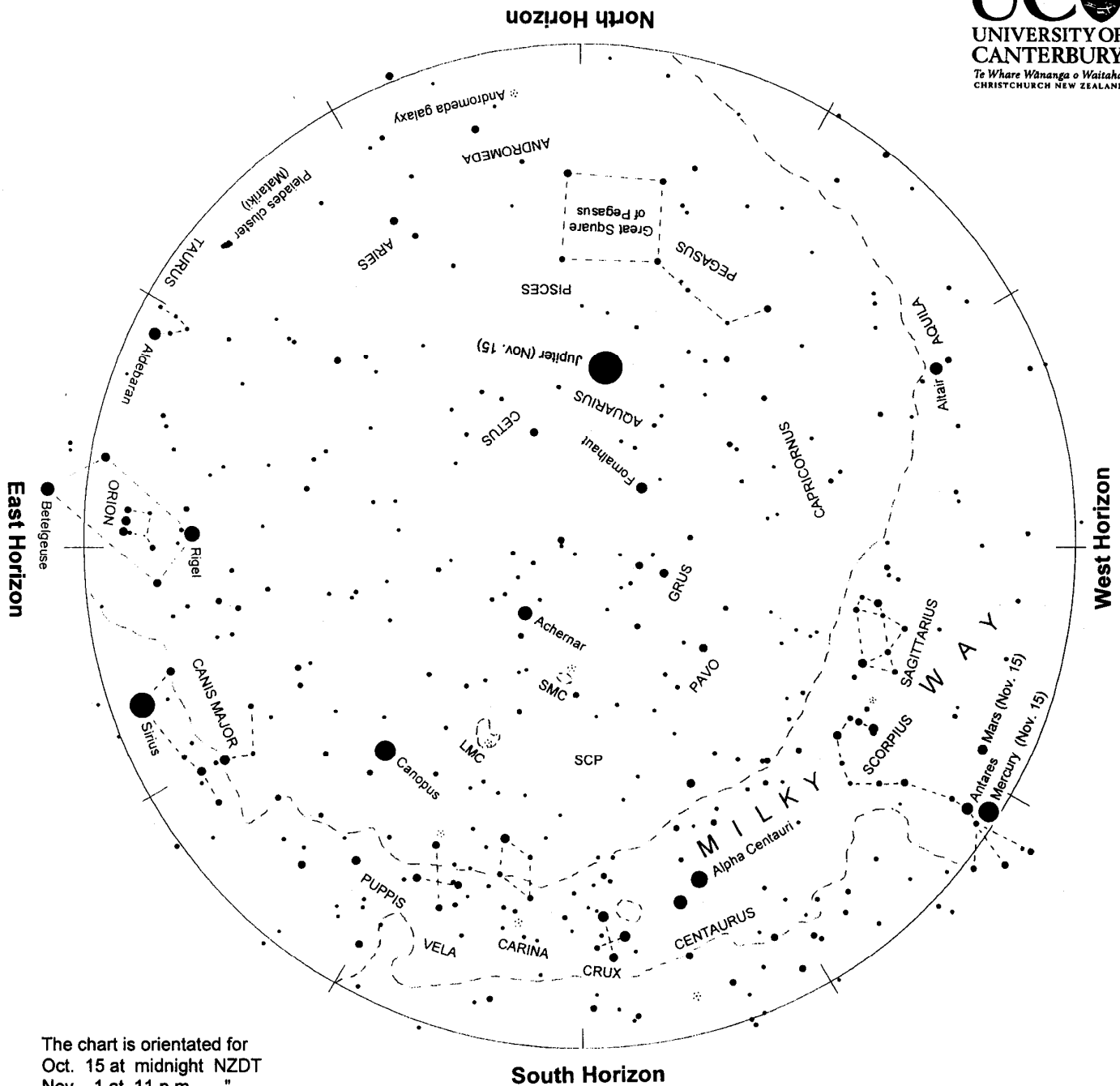
Society Telescopes For Hire

The Society has a wide range of telescopes for hire to members.

If you are looking to purchase or upgrade a telescope and are not sure what to buy, this is a very good way to evaluate some of the available equipment. See also the advertisement on the back page.

To inquire about hiring or for advice on what to buy and for information about equipment, contact Ivan Vazey, curator of instruments, at ivazey@surfer.co.nz ph (09) 535-3987





The chart is orientated for
 Oct. 15 at midnight NZDT
 Nov. 1 at 11 p.m. "
 Nov. 15 at 10 p.m. "

Evening sky in November 2010

To use the chart, hold it up to the sky. Turn the chart so the direction you are looking is at the bottom of the chart. If you are looking to the south then have 'South horizon' at the lower edge. As the earth turns the sky appears to rotate clockwise around the south celestial pole (SCP on the chart). Stars rise in the east and set in the west, just like the sun. The sky makes a small extra clockwise rotation each night as we orbit the sun.

Jupiter is the first 'star' to be seen after sunset, north of overhead. It sets in the west around 3 a.m. Mercury and Mars, and the star Antares, play tag on the southwest skyline at dusk. The Milky Way is wrapped around the horizon. It is low in the west and south sky early in the night. As the western portion sets the eastern part comes into view. Along with it rise Sirius, the brightest star, twinkling like a diamond, Orion (containing 'The Pot'), Taurus and the Pleiades/Matariki star cluster. The Pointers and Crux, the Southern Cross, are low in the south. The north sky is empty but for the Great Square of Pegasus with the Andromeda galaxy nearby.

Chart produced by Guide 8 software; www.projectpluto.com. Labels and text added by Alan Gilmore, Mt John Observatory of the University of Canterbury, P.O. Box 56, Lake Tekapo 7945, New Zealand. www.canterbury.ac.nz

Solar System Events for November 2010

Source RASNZ Diary events derived from Dave Herald's OCCULT 4

Date (NZDT)	Diary of Solar System Events in November 2010 for New Zealand
November 2	Crescent Moon 26% lit, 9° to right of Regulus magnitude 1.4, morning sky.
November 4	Moon at perigee, its closest to the Earth for the lunar month, 364194 km.
November 6	New Moon at 5.52am NZDT (4:52 UT).
November 7	Neptune stationary.
November 8	5.5% lit crescent Moon, 5° above Mars and 4.5° to right of Antares, magnitude 1.1, low in early evening sky.
November 9	Moon furthest south, so highest southern hemisphere transit for the month.
November 11	Mars 4° to lower right of Antares, low in early evening sky.
November 14	Moon at first quarter at 5.38am NZDT (Nov 13, 16:38 UT).
November 15	Moon at apogee, its greatest distance from the Earth for the Lunar month, 404634 km.
November 16	Mercury magnitude -0.4, 2.6° to right of Antares, magnitude 1.1, very low early evening sky.
November 16	75% lit Moon 7° below Jupiter, and Uranus, late evening sky.
November 17	Venus stationary.
November 19	Jupiter stationary.
November 20 & 21	Mercury magnitude -0.4, 1.7° to left of Mars, magnitude 1.4, very low in dusk sky.
November 22	Full Moon at 6.27am NZDT (Nov 21, 17:27 UT).
November 23	Moon furthest north, so lowest southern hemisphere transit for the month.
November 29	Crescent Moon 52% lit, 6° to upper right of Regulus magnitude 1.4, morning sky.
November 29	Moon at last quarter 9.36am NZDT (Nov 28, 20:36 UT).
November 30	Moon at perigee, its closest to the Earth for the lunar month, 369428 km.

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<http://pigeonmountainobs.co.nz>
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Wheelbarrows and Telescopes

A Review of an ASTRONZ 8" Dobsonian Refractor

By Simon Lowther

I have been fortunate enough to have used a few different telescopes of varying types, some weird and others seemingly mundane, and have found that they share a commonality with wheelbarrows; while some scopes perform well on some tasks, like wheelbarrows, they do a less than adequate job on others; and hence man can never own too many telescopes (and possibly wheelbarrows, though I still reserve judgment on this). This was the angle I used to try to convince my wife that I did indeed need another scope, and while she did not swallow it for a second, she was smart enough to realize that I was going to buy another, regardless.

I enjoy numerous activities in astronomy, and currently tie up my only instrument on fine nights with the gathering of data for astrophotography and photometry, amongst other endeavours. While the scope attends to these tasks largely without my assistance, I am left with a clear sky and no glass to look at it through. So it was decided that I required another scope which was all the things my current one is not; portable, easy to set up, easy to share with others, and most importantly, not able to be used with anything other than an eye as a detector. It would seem that I did not have to look far for such a scope, as I ended up with an ASTRONZ 8" Dobsonian. These are imported by the Auckland Astronomical Society from GSO in Taiwan, a company who also supplies many of the parts for the better known brands.

I collected the telescope from Auckland Observatory, and in typical schoolboy fashion (though I have been out of school for many years), the boxes were opened as soon as they arrived home. The telescope was well packaged in two boxes, one for the mount and the other for the optical tube. No instructions were to be had in any of the boxes, and are acquired separately from the reseller. I was not waiting for said instructions, and had the telescope assembled in less than an hour. The mount is rather easy to put together, as it is simple flat pack furniture. I would not suggest anyone try

the same thing, but I do think it illustrates how easy one of these telescopes goes together.

The mount is made from medium density particle board, which was expected but still a little disappointing. Veneer protects the MDF from dew, and it should last many years if looked after appropriately. It is very solid and has a nice adjustable roller bearing for pointing in azimuth. Older versions of this telescope have a spring for altitude tension, while newer telescopes have a rather nice altitude bearing with internal tensioning. An adjustment for balance is also provided, which was a nice surprise.

The OTA is preassembled and slides easily onto the mount. The design of the OTA to mount assembly is simple but very effective. On the OTA is a nice Crayford focuser adaptable for both 2" and 1.25" eyepieces. The focuser uses a brass compression ring to hold an eyepiece in place, something that is not included on scopes which cost more than 20 times this one. The finder is attached to a quick release bracket. Unfortunately this bracket slides up into position, meaning a bump to the locking screw could cause the finder to fall out. While very unlikely to occur, a simple design change would give 100% safety in this area.

Also included in the package are two eyepieces, a 25mm and 9mm super plossl. I think these sizes are nicely matched to the scope to give both wide field views and moderate power views.

On the rear of the scope is a small fan to aid in the cooling of the optics. It is operated by a small battery pack (batteries not included) and apparently does make a significant difference to the cool down time. I am not sure, however, if mine will ever see use. The scope came out of the box with nearly perfect collimation. Collimating the secondary is standard with small Phillips head screws. The primary has convenient collimation knobs and locking knobs. Care must be used with the locking knobs, to tighten them a little at a time, as the collimation can drift if they are tightened all the way



in one go. Construction of these parts appeared to be more than adequate.

The Auckland weather has been uncooperative for several months now, but I have managed a few looks. Taking the scope outside and readying it for use takes less than 2 minutes, which means it will get plenty of use! Pointing is smooth, and it suffers from virtually no sticking, which traditionally has been the "royal pain in the optics" of all Dobsonian users. Following objects is therefore easily accomplished by first time lookers.

Without going into painful details, all the objects I have viewed have been crisp and clear. The optics have performed as an 8" scope ought to. All my expectations were met, and it ticked all the boxes as far as ability to draw people to the eyepiece and enjoy the view.

This telescope fits the bill very well. It would perhaps be a little unfair to compare it to a Meade ACF or Ritchey-Chretien scope, costing more than 20 times the outlay for this telescope, but it has outperformed all others in one area hands down, being the 'bang for your buck' category. When purchasing this scope you get every dollar's worth and far more. It may not reach dream scope status, but I am more than proud to tell people that I am an ASTRONZ Dobsonian owner.

History of Spectroscopy

By Dr Bernie Brenner

1 Introduction

1.1 What is spectroscopy?

Spectroscopy is the analysis of light as a function of wavelength. It is a “map” of brightness plotted against wavelength or frequency (Moore 2002). It is a tool for gathering data about the chemical composition, the physical conditions and radial velocities of astronomical objects. Generally spectroscopy covers the visible electromagnetic spectrum between the range of 0.4 μm to 0.7 μm . Of course more sophisticated spectroscopy can encompass far ultraviolet 0.1 μm to far infrared 100 μm . Beyond this range there is also X-ray and gamma-ray spectroscopy. High energy gamma and x-ray are usually plotted against energy (Kev) rather than wavelength.

As regards spectrography, a spectroscope is fitted to a reflecting telescope which serves as the light detector. The image of the celestial body is focused onto a spectrograph slit which improves the spectral resolution by limiting the region under study and reducing the influence of extraneous light from the night sky. The diverging light beam passes from the slit to a collimator (or lens), which produces parallel light. This is dispersed by the diffraction grating which focuses the spectrum onto a detector. This may be a charge-coupled device or an electronic array.

If the image of a star is focused onto a spectroscope’s slit, there is a limitation of other objects in the night sky. This limitation improves spectral resolution.

Dispersion is the spectrum’s length. It is controlled by two factors. The first is the magnification of the eyepiece. A shorter focal length eyepiece will produce a longer spectrum. The second is the distance between the field lens of the eyepiece and the diffraction grating. If this distance is increased then the spectrum will lengthen.

3 types of spectra have been described (Heckert 2007).

A continuous spectrum has no sharp changes in brightness at varying wavelengths.

An emission spectrum is dark at most wavelengths but is bright at specific ones. They occur with hot transparent gases so the application in astronomy is the assessment of nebulae, which are interstellar clouds of gas at very high temperatures.

Absorption spectra look like continuous spectra but have certain wavelengths missing. The dark lines formed are the absorption lines. They occur when light with a continuous spectrum passes through a transparent gas that is cooler.

Most stars have absorption spectra because they have hot cores with cooler surface layers. The chemical composition of stars can thus be determined with this analysis.

There are two main types of spectroscopes, those using prisms and those using diffraction grating.

Prisms were most commonly used in the early part of the last century. Most of the stellar classification catalogues were created from prism spectroscopes. These produce a single spectrum which is not linear. Refraction is used to disperse the light into constituent colours. The red end of the spectrum is foreshortened while the blue end is broadened. The diffraction grating units, on the other hand, produce many spectra which are all linear (the distance between wavelengths are of equal separation, no matter what part of the spectrum is being inspected). There are two types of diffraction gratings. The first is produced on a glass or plastic substrate, where the light passes through the optic diffracting the light on the opposite side. The second type has lines ruled on glass and it is then aluminized so that it diffracts and reflects light concurrently.

Diffraction gratings produce many spectra on both sides of the light source and these are referred to as 1st, 2nd, 3rd orders. The groves in the grating can be

bevelled in such a way as to reflect or refract most of the energy in the direction of the preferred part of some particular order. This is known as the “Blaze” (Malpas 1996).

1.2 The importance and contribution of spectroscopy to astronomy

It is claimed that about 90% of everything we know about the stars has been learned through spectroscopy (Caussade 2004). This may be somewhat of an overstatement but there can be no doubt that spectroscopy is one of the most valuable tools of the astronomer. By breaking down light into its components, its spectral features can be identified. As an example using Wien’s law (Freedman and Kaufmann 2008)

$$\lambda_{\text{max}} = 0.0029 \text{ K m} / \text{T}$$

we can derive a blackbody’s temperature given only the shape of a spectral curve (plotting intensity versus wavelength).

In modern times, with the advent of the laser, atomic and molecular spectroscopy provides a more sophisticated tool and when coupled with Doppler techniques, the value increases exponentially.

This project will trace the development of this field of astronomy from Newton to the modern day.

2 A review of the development of spectroscopy from Newton to modern day

2.1 The Early Development

It is appropriate to start with the discovery of Isaac Newton (1642 – 1727), the greatest of all known scientists. In 1666 he showed that white light could be split into a continuous series of colours and he coined the term “spectrum” to describe this (Feld 2009). The word he borrowed from Latin meaning apparition or spectre. Using a glass prism and with a small hole in the window shutters he allowed light to pass through the prism. The resulting spectrum produced a rainbow of colours.

Newton then allowed only one colour in the resultant spectrum to pass through a second prism. The light that emerged from the second prism was the same colour as the light that had entered. The common belief at the time was that prisms added colour to light but this experiment showed that white light was

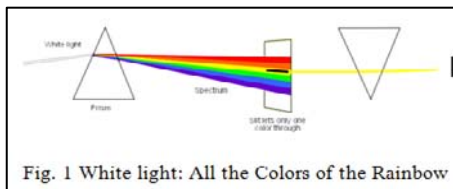


Fig. 1 White light: All the Colors of the Rainbow

separated into its constituent colours. It is remarkable that Newton was only 23 years old at the time of these experiments.

Nothing much happened with this "spectrum" for over a 130 years. The golden age of spectroscopy was about to start.

Then in 1801 Thomas Young (1773-1829) performed experiments that are now called "Young's double slit experiment". When light was passed through a slit and then two narrow slits, a series of alternating dark and light bands was projected on a screen. This showed the wave-like nature of light. William Wollaston (1766 – 1828) in 1802 observed dark lines in the solar spectrum. He interpreted the dark lines as gaps separating the colours of the Sun. He was a chemist and mineralogist

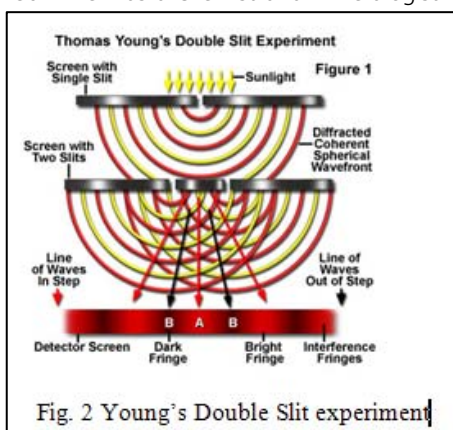


Fig. 2 Young's Double Slit experiment

and also a medical doctor. It is to him the honour goes for the very first observation of spectral lines.

The biggest jump in the history of this technology now develops with the advent of Joseph von Fraunhofer (1787 – 1826). (Fig 3 Fraunhofer demonstrating the spectroscope).



Fig 3 Fraunhofer demonstrating the spectroscope

It is documented that at the age of 24 years, this optical instrument maker set up a telescope and allowed a slit of light to enter the front of the instrument. With a prism in front of the telescope he saw not only the expected spectrum but also "an almost countless number of strong and weak vertical lines..." (Joiner 1988). Fraunhofer did not really know what caused these lines and that mystery would only be solved later. His other great contribution, however, was the invention of a diffraction grating. The grating had 3200 lines etched into a piece of glass and this was able to provide better detail of the spectra (the differences between prisms and diffraction grating have been detailed above).

It took nearly fifty years before Gustav Kirchhof (1824 – 1887) and Robert Bunsen (1811 - 1899) collaborated to show that every chemical element could create a unique spectral pattern. Kirchhof in particular performed experiments that demonstrated absorption patterns for sodium, iron, calcium, nickel and chromium. He was able to "break the code", so to speak, of Fraunhofer's dark lines. At this time also we need to acknowledge James Clerk Maxwell (1831 - 1879), who revealed the nature of light as an electromagnetic wave and A J Angstrom (1814 - 1874) who, in 1868, published improved wavelengths for solar spectrum lines. In 1885 Johan Jakob Balmer (1825 - 1898) developed an interest in Fraunhofer's hydrogen lines. He used Angstrom's measurement of hydrogen lines and developed a formula for measuring the wavelength in metres.

$1/\lambda = R(1/4 - 1/m^2)$ where λ is wavelength, R is the Rydberg constant (1.097×10^{-7}) and $m = 3,4$ etc (for the lines from the red end).

So after a gestation period of nearly 200 years we can announce the birth of spectral analysis.

2.2 The Doppler Shift and Spectroscopy

2.2.1 Discovery of the Doppler Shift

It is chronologically appropriate at this time to examine the Doppler shift. Christian Doppler (1803 – 1853) in 1842 discovered the effect of motion on sound waves. Applying this so called Doppler effect, Armand Fizeau (1819 – 1896) showed that the Doppler effect would cause the lines in a star's spectrum to shift.

In simple terms, any wave pattern has wavelength and frequency. By multiplying wavelength and frequency you get speed. In the case of light, a higher frequency means blue light where wave crests are closer, resulting in a shorter wavelength and an observer moving towards the source has the same effect. If the wave crests are farther, resulting in longer wavelengths, the waves are red-shifted with an observer moving away from the source giving the same result. A shift in the observed wavelength / frequency is called the Doppler shift.

$$\lambda = c/f$$

$$c\lambda = 1/f$$

$$\lambda' = c / f + v/f$$

$$\lambda' = \lambda(1+v/c)$$

where λ = original wavelength

λ' = observed wavelength

f = frequency

c = speed of waves

v = vector speed of object

The application of Doppler shift in astronomy has been enormous. By observing a spectrum of a star and comparing the observed wavelengths of the absorption lines to known values, the star's radial motion can be calculated. Some modern applications are discussed later.

2.2.2 The expansion of the Universe

Edwin Hubble (1889 – 1953) and Milton Humason (1891 – 1972) using the Doppler Shift noted that light spectra from other galaxies increased their red

shift proportion to a particular galaxy's distance from the Earth (Hubble's Law) – this led to the discovery that the Universe is expanding. Hubble unfortunately was not awarded the Nobel Prize because during his lifetime astrophysics was not eligible for an award in physics and only became so after Hubble's death. Humason had no formal training in astronomy.

2.3 The history of the classification of spectra

2.3.1 The age before photography

In 1863 William Huggins (1824 – 1910) showed that stars like the Sun contained elements like sodium, iron and calcium. Because of the decoding of spectra, it was necessary to have some classification of the stars that fitted into categories. The Catholic Church, which only 400 years previously had condemned Galileo to house arrest for his support of a heliocentric model, now provided the means of classifying spectra. Father Angelo Secchi (1818 – 1878), a physicist and Jesuit classified stars as Type I, II, III and IV based on their colour, width, and absorption lines in the spectrum. He deduced that all fixed stars would vary according to their physico-chemical nature and reduced to the spectral types above (Pohle 1912). He is also famous for the invention of new astronomical instruments, which included a star spectroscope.

Norman Lockyer (1836 - 1920) famous for naming the element helium, related spectral classes to temperature. Spectral classes with increasing temperature started with nebulae and then stars with banded spectra and hydrogen line spectra. On with decreasing temperature there were stars that cooled and a crust formed on their outer layers (SAO 2010).

2.3.2 After the invention of photography

The first successful picture was produced in 1827 by Nicéphore Niépce (1765 – 1833). He unfortunately died a short while later and his partner Louis Daguerre (1787 – 1851) developed the Daguerreotype. The Calotype was invented by William Fox Talbot (1800 - 1877) and for the first time an unlimited number of positive prints could be made (Leggat 1995).

The technology of photography would revolutionize the study of astronomy and without its invention it is doubtful that spectroscopy would have progressed because naked eye observation had a rather limited place in the analysis of spectra.

A medical physician and amateur astronomer, Henry Draper (1837 - 1882) took advantage of the new invention of photography and began photographing spectra. In 1872 he photographed the spectrum of the star Vega. This was the birth of the spectrograph. On his premature death his widow set up a Memorial Fund to finance the study of spectrography and classification of spectra at the Harvard College Observatory. It is interesting to reflect how a technological advance in a totally unrelated field had such a dramatic impact on astronomy.

2.3.3 The late 19th and early 20th centuries

2.3.3.1 Naming the Stellar Family

Edward Charles Pickering (1846 – 1919) had been professor of physics at MIT and then moved over to Harvard, where he conceived of and initiated the Maury Harvard project. His contribution to this relatively new branch of astronomy was truly phenomenal. He constructed a spectrograph at the Harvard College Observatory by attaching prisms to the telescopes and captured the images on photographic plates 25 x 20 cm (Joiner 1988). He designed a new technique by placing prisms over the whole incoming light and so facilitated the gathering of spectra. It is at this point that an interesting development occurs in the history of spectroscopy. Pickering hired a crop of women employees who became known as "Pickering's harem" (Welther 1982). Why all women? There were probably two reasons – the first was a stereotypical view that women were more suited to the "tedious calculations and measurements necessary to determine the wavelengths of the spectra on black and white plates" (Joiner 1988).

(Fig 4 Pickering's Harem).

The second reason, probably as a reflection of cultural relativism, Pickering



Fig 4. Pickering's Harem

was able to employ them at relatively low rates of pay. It would, in fact, take many decades for pay equity to occur between the sexes in astronomy and for that matter in many other areas. (An exception here was at the US Naval Observatory, where in 1892 women were paid the same as men but nevertheless at this same facility, women were banned from using the telescopes (SAO 2010). This leads us to the next section where we examine the contribution of women to spectroscopy.

2.3.3.2 The Female Contribution in the spectral process

As already alluded to above, women at the turn of the 19th Century faced many difficulties in working in astronomy. Pickering employed mainly women to help him devise a more detailed system of classification than had been devised by Secchi. Pickering's attitude to his female employees can clearly be gauged by the following quote: "...the most appreciated lady became the one who dutifully carried out the routine work of classifying exactly as she was told, while another slowly made independent new discoveries that Pickering would not accept, even after other astronomers proved them highly significant." (Hoffleit 2002).

It is ironic really that the reason women gained a foothold into the world of astronomy was that they were available as cheap labour and because they were willing to perform tedious clerical and technical duties and "...those with ability for this women's work were given special acclaim, while their trailblazing scientific discoveries often received scant recognition." (Gordon 1978).

Williamina Fleming (1857 – 1911) was Pickering's chief assistant. She compiled

the Draper Catalogue of Stellar Spectra in 1890. It is interesting to note that Pickering's name went on the cover and Fleming was only mentioned in the introduction (Gordon 1978). This project subdivided Secchi's original four types into 13 classes denoted by alphabetical letters.

Antonia Maury (1866 – 1952), who was a niece of Henry Draper, and had trained in physics and chemistry at Vassar College, worked with Pickering on a catalogue of 681 bright northern stars. She developed a more complex classification but she apparently did not get along with Pickering and left Harvard in 1896. In 1943 the MKK system incorporated Maury's classification subdivisions into a revised version of the Draper scheme (Morgan, Keenan et al. 1943).

The story continues with Annie Jump Cannon (1863 – 1941). Oh, Be A Fine Girl – Kiss Me! is the mnemonic developed from the work of this famous female astronomer. She simplified Maury's classification and her Draper catalogues listed nearly 400,000 stars. She also published a catalogue of variable stars (Maisel and Smart 1997).

The contribution of the above three astronomers is notable, not only for the fantastic contribution in "describing and organizing hundreds of thousands of stars [that] formed the backbone of modern astronomy" (Joiner 1988), but especially because they were women at a time when a woman's place was decidedly in the kitchen or in the laboratory doing menial tasks with low pay and poor recognition for their scientific contribution. For them to have accomplished so much despite the hurdles, is even the more commendable.

In 1896 Pieter Zeeman (1865 – 1943) found that some spectral lines were split into 2 or 3 lines due to a strong magnetic field. He was awarded the Nobel prize in 1902 for the discovery of the Zeeman effect.

2.3.4 The Early 20th century

Walter Adams (1876 – 1956) and Arnold Kohlschutter (1883 – 1969) in 1913 working at the Washington Mount Wilson Observatory, noted that some

spectral lines varied in intensity with respect to each other in stars of the same spectral class. They worked on the "spectroscopic parallax" but unfortunately World War I resulted in Kohlschutter becoming a prisoner of war while returning to Germany and he was prevented from ever returning to Mt. Wilson (Brashear 1991).

In 1913 Niels Bohr stated that the frequencies of spectral lines were always expressible as the difference between two quantities and that emission frequencies were determined by a single universal constant (Feld 2009).

Ejnar Hertzsprung (1873 - 1967), a Dane, trained as a chemical engineer and was actually interested in the chemistry of photography. This serendipitous interest led him to stellar photography and in turn to astronomy. He felt that "the intrinsic brightness of stars might parallel their spectra and temperatures" (Joiner 1988) meaning that the cool red stars were the dimmest. On consulting one primary source, Hertzsprung takes credit for the discovery of "giants and dwarfs" (Hertzsprung 1922). Henry Norris Russell (1877 – 1957) had been working independently of Hertzsprung and came to similar conclusions as Hertzsprung.

They would both be immortalized in what became the "Hertzsprung-Russell diagram".

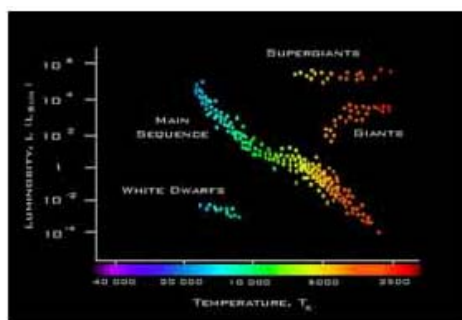


Fig 5 Hertzsprung-Russell diagram

This is really an important development in the history of astronomy as a whole. When you plot stellar luminosity against spectral class (colour and temperature), stars fall into different groups. On the vertical axis brighter stars appear near the top and the fainter ones near the bottom. Star temperatures decrease from left to right. Most of the stars fall into a central band called the main

sequence and the remainder of stars are scattered into the upper right quadrant where the bright cool giants and supergiants exist and the hot dim white dwarfs in the bottom left quadrant. Although they were both wrong regarding stellar evolution, their contribution to astronomy in the early 20th Century was enormous.

It was Arthur Stanley Eddington (1882 - 1944), with his work in atomic theory and using Albert Einstein's (1879 – 1955) $E = mc^2$, who, refuted Russell's theories. However, it was a woman graduate of Harvard who using the large collection of stellar spectra from the university's collection in 1925, noted that the most abundant element in the Sun and other stars was hydrogen. Celia Payne (1900 - 1979) had provided the foundation for current theories about the evolution of stars and galaxies (Joiner 1988).

2.3.5 The Era of Modern Spectroscopy

2.3.5.1 Laser and Linewidth

From after World War 2 to date the advance of technology has been incredible. The invention of the laser, which was an extension of the maser, a microwave oscillator was developed by the Russians, Nicolay G Basov (1922 - 2001) and Alexander M Prokhorov (1916 - 2002). They were awarded the Nobel Prize in Physics in 1964. As an aside note, Prokhorov was actually born in Queensland, Australia but returned with his family to Russia in 1923.

In modern days the linewidth of a laser (usually a single-frequency laser) is the width of its optical spectrum. It has applications in spectroscopy and also with fiber-optic sensors and for testing and measurement (Paschotta 2010).

2.3.5.2 Galaxy kinematics from internal velocity dispersion measurements

The first rotation curve was obtained in 1918 using emission spectra of the Andromeda nebula. Later, with the advent of CCDs, larger telescopes and interferometry, it was possible to obtain radial maps in emission lines in relatively short times. The kinematic behaviour and stars can be different and can inform on the structural evolution of the galaxy (Beckman, Zurita et al. 2004)

2.3.5.3 Stellar ages

Astronomers, using integral field unit spectrographs, are able to measure stellar population ages down to $\mu\text{v} \sim 24 \text{ mag arcsec}^{-2}$ (Yoachim, Roskar et al. 2010)

2.3.5.4 Metallicities

Low and high resolution spectroscopic studies of individual stars in the Milky Way and dwarf galaxies can provide measurements of overall metallicity and elements. This is important to help understand galaxy evolution and how the metallicities of stars in physically different environments develop with time (Starkenbug, Hill et al. 2010).

2.3.5.5 Modern Redshift surveys

Galaxy redshift surveys are of vital importance in cosmology today (Lahav and Suto 2004). Two current large galaxy surveys, the 2dF and SDSS, have enhanced astronomers' knowledge of the Universe. The surveys are regarded as having unprecedented quantity and quality, with up to 100,000 spectroscopic assessments of galaxies and quasars. They have also helped in the understanding of gravitational evolution of dark matter and also address "the evolution of visible objects from the analysis of their redshift surveys separately from the nonlinear growth of the underlying dark matter gravitational potentials" (Lahav and Suto 2004).

2.3.5.6 Spectroscopy outside the optical wavelengths

2.3.5.6.1 The Hydrogen 21 cm line

The hydrogen line, 21 cm line or H1 lines refers to the spectral line created by changes in the energy state of neutral hydrogen. It is outside the optical electromagnetic spectrum and lies in the radio region. Its ability to penetrate dust clouds is particularly valuable in astronomy and with Doppler shift can calculate the relative speeds of the arms of the Milky Way.

In the 1930's a radio hiss was noted and in 1940 Jan Oort (1900 – 1992) published data showing that the noise seemed to be coming from the centre of the Galaxy. In 1944 Hendrik van de Hulst (1918 – 2000) discovered that neutral hydrogen could produce radiation at a

frequency of 1420.4058 MHz. The 21 cm line was first detected by Harold Ewen (1922) and Edward Purcell (1912 – 1997) in 1951 and in 1952 the first maps of neutral hydrogen in the Milky Way were developed showing its spiral structure.

2.3.5.6.2 Infrared Spectroscopy

This deals with the infrared part of the electromagnetic spectrum. It is outside the optical range. The initial discovery is attributed to William Herschel (1738 – 1822), who in 1800 noted that when he used a red filter to observe the sunspots, a lot of heat was produced. He discovered infrared radiation by passing sunlight through a prism and holding a thermometer just beyond the red end of the visible spectrum. The development of this modality in astronomy was, however, slow and only in the early 1900's did Seth Nicholson (1916 - 1957) and Edison Pettit (1889 - 1962) develop thermophile detectors capable of accurate infrared photometry and thereafter only after the advent of radio astronomy later on.

Modern infrared telescopes need to be chilled with liquid nitrogen (or helium) as radiation from the telescope itself can cause "noise". To achieve higher angular resolution these type of telescopes are often combined to form astronomical interferometers. The Earth's atmosphere limits the sensitivity of infrared telescopes as water vapour absorbs infrared radiation and for this reason they are often located at high altitudes. Their natural location, however, is in space and they have been placed on the Herschel Space Observatory, the Spitzer Space Telescope and the Wide-field Infrared Survey Explorer.

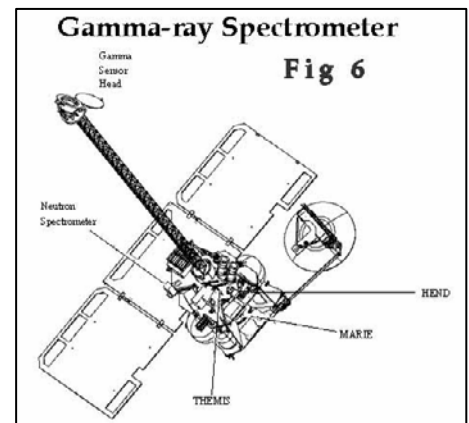
2.3.5.6.3 X-ray Spectroscopy

This deals with the X-ray portion of the electromagnetic spectrum. Karl Siegbahn (1886 – 1978) won the Nobel Prize for Physics in 1924, for his discovery of X-ray spectroscopy. X-Ray sources are extensive. They include galaxy clusters, black holes in active galactic nuclei, supernova remnants, binary stars containing a white dwarf and a neutron star or black hole. Of particular relevance to spectroscopy is the high resolution gamma-ray and hard X-ray spectrometer

(HIREGS), which was designed to obtain spectra of Solar Flares and the Galactic Centre. It was launched from Antarctica in 1991. There have subsequently been other balloon or satellite based X-ray telescopes. The high-energy focusing telescope (HEFT) was balloon-borne and launched in 2005.

2.3.5.6.4 Gamma Ray Spectroscopy

Gamma rays are absorbed by the Earth's atmosphere and must be studied via telescopes in space. The first gamma-ray telescope was launched into space in 1961. Since then there have been many subsequent launches. The Fermi Gamma-ray Space telescope is a space observatory used to perform observations from a low Earth orbit. It was launched in 2008 and has on board a Gamma-ray Burst Monitor which can detect bursts across the entire sky. Gamma-ray spectrometers (fig 6 Gamma-ray Spectrometer) have been extensively used to analyse elements and isotopes of airless bodies in the Solar System and especially of the Moon and Mars.



3 Conclusion

It has been claimed that about 90% of everything we know about the stars has been learned through spectroscopy. The term spectrum was introduced by Isaac Newton in 1666 when he used a prism to split light. One hundred and thirty-five years later, Young and then Wollaston experimented further but the biggest jump in the history of spectroscopy came from Fraunhofer, who in 1811 demonstrated strong and weak vertical lines in the spectrum of the Sun. The golden age of spectroscopy had begun. Kirchhof, Bunsen, Maxwell and Balmer all made very significant contributions in

the early 19th Century, culminating in what could reasonably be called the birth of spectral analysis. The Doppler shift appears at around this time as well and before the use of photography in spectroscopy, William Huggins and Father Angelo Secchi lay foundations for classifying spectra into categories. The advent of photography would revolutionize spectroscopy and heralded the invention of the spectrograph. The American physician Henry Draper began photographing stars. On his premature death his widow set up a Memorial fund at Harvard allowing Pickering to employ "cheap labour" in the form of women.

This all happened in the late 19th Century and resulted in a comprehensive classification of spectra to occur. The female contribution from the likes of Fleming, Maury and Cannon is acknowledged especially for the poor pay, conditions and blatant sexism (as was the norm at that time).

The early 20th Century delivered further significant contributions by Bohr and then Hertzprung and Russell, with the famous Hertzprung-Russell diagram coming into being. The 1920s saw progress in atomic theory by Eddington and then with Payne providing the basis for the current theories about star and

galaxy evolution.

After the 2nd World War the advance in scientific technology and for that matter in spectroscopy has been enormous. LASER and other technological advances have elevated spectral analysis to incredibly high levels of sophistication and have advanced our understanding of the Universe in unimaginable ways.

Note: The references have been omitted to save space. Those of you that would like to see the list of references can email Dr Brenner directly at: gynaecology@xtra.co.nz. ED

Black Saturn

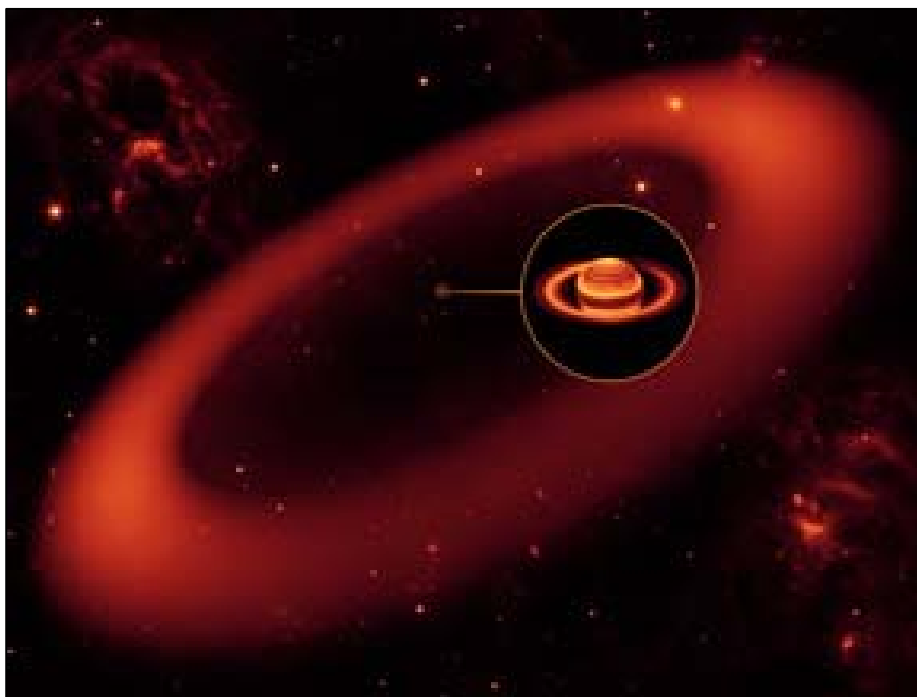
From 'The Observatory' Correspondence 2010 April p.89.

Saturn's Phoebe Ring and Ancient Babylonian Observations

Article provided by Alan Gilmore, RASNZ Newsletters

The Spitzer Space Telescope recently discovered an enormous 'ghost' ring (also known as the Phoebe Ring) around Saturn. With a radius of between 128 and 207 times that of Saturn, a vertical thickness 40 times Saturn's radius, and an inclination of about 17 degrees with respect to the main ring plane, it incorporates Saturn's moon Phoebe, from which the dust is thought to derive through impacts. Some 100 times the diameter of the nearest rings inside it, at opposition it is estimated to "span the width of two full Moons' worth of the sky, one on either side of Saturn". At present the ring is visible only in the infrared, yet we wonder whether its discovery might shed some light on an unsolved problem in archaeoastronomy.

Ancient astronomers assigned specific colours to each of the traditional seven (naked eye) planets. The earliest documented examples come from the Cuneiform texts of the Babylonians and Assyrians, dating to the 8th-7th Centuries BC. In an on-going project we have been studying the rationale behind the colours assigned to each planet and in most cases there is a straightforward naturalistic explanation. For example, the Babylonians systematically described the Sun as gold, the Moon as silver, Mars as red, and Jupiter as white, just as they



This is how an artist thinks the Phoebe ring might look if we could see it. The Spitzer space telescope spotted the Phoebe ring. Spitzer can "see" infrared "light". Saturn and the other rings are just a tiny dot compared to the Phoebe ring. The inset picture shows Saturn magnified. Image courtesy of NASA/JPL/Space Science Institute

appear. The 'green' colour ascribed to Venus can be read as green or blue, as there was no distinction between the colours in the Sumerian and Akkadian languages used by the Babylonians. While Venus generally appears white, this could shift to a greenish-blue tinge

to the unaided eye, as confirmed by ethnographic parallels outside Babylonia. Though less clear from the sources, our understanding is that Mercury was associated with pale red (brown, according to the medieval scholars of Harran in north-western Mesopotamia),

and the planet can appear orange-brown in colour.

The colour assigned to Saturn remains a distinct problem. The Babylonians regularly described it as 'black'[4], as did ancient Indian and Graeco-Roman and medieval Jewish writers (working within traditions influenced by the Babylonians). Saturn is indeed a dim planet (compared with Venus, Jupiter, and Mars), but nonetheless its visibility led to its observation, a circumstance which hardly prompts association with black! Besides, comparison with the other planets suggested that the Babylonian 'planet colours' were not based on degrees of brightness, but on actual colouration. If anything, Saturn appears yellowish in colour, yet only one of the ancient sources we have examined (Plato, "Republic", 10.14) suggests a yellow colour.

We have experimented with astrological and cosmological explanations (in Babylonian terms) for the widespread choice of black for Saturn. For example, the Babylonians commonly distinguished between planets thought to be 'benefic' (Jupiter and Venus) and 'malefic' (Saturn and Mars, Mercury being ambiguous). As the most auspicious planets were also the two brightest, one might suspect a correlation between relative brightness and beneficence, with the 'malefic' planet Saturn being assigned the darkest colour possible. Yet this does not seem satisfactory, as it flouts the underlying logic that can be seen in the colour choice of all the other planets, where, clearly, natural appearance has dictated the choice.

The reconstruction offered of the newly-discovered Phoebe ring is thus of immense interest, not only to modern astronomers, but for those studying the thought processes of their ancient counterparts. As visualized, a ring of light surrounds a gigantic black space, within which the planet itself appears only as a small dot of brightness at the centre. Though the ring is presently invisible from a terrestrial standpoint, were anything like this to have been visible from the Earth in the ancient past, an explanation would readily have offered itself as to why ancient observers regarded Saturn as black: perceiving the ring as the perimeter of the planet, the 'body' of the object would appear to be black. Could the amount of dust in the Phoebe ring have been considerably larger in the recent past due to an episode of cometary or asteroidal impact activity? If so, could sunlight have reflected off the particles on a process akin to the zodiacal light, producing a ring, at least partially, as seen from the Earth? The optical form of the ring might have varied between an arc and an oval if only a part of the ring was illuminated, due to different perspectives on the ring as seen from Earth.

Not only would this successfully account for the Babylonian characterization of Saturn as 'black', it might also shed light on some other curious traditions. The Greek historian, Diodorus of Sicily (1st Century BC; "Bibliotheca, 2.30.3) stated that the ancient Babylonian astrologers deemed Saturn epiphanéstatos or 'the most conspicuous' of planets -- a qualification that has remained elusive. Babylonian astrologers linked the planet to the Sun, a puzzling fact that has

exercised scholars' minds for a century. Saturn was called the planet of the Sun-god Shamash by the Babylonians, followed by the writers in the Greek world ('the star of Helios') and in India ('son of the Sun'). The ring, greater than the Moon if visible, could have prompted the Babylonian perception of Saturn both as a nocturnal Sun and black. Another puzzling tradition associated with Saturn comes from Hellenistic Egypt; it concerns a type of comet called the 'discus', described as round and golden, with rays around its circumference, and named after the planet Kronos (Saturn) because of its similarity in appearance. Could this association have originated at a time when Saturn was still envisioned in terms of the ring?

The overriding question is whether such a ring could once have been seen by terrestrial observers? What mass of dust would be required, distributed around Phoebe's orbit, to scatter sufficient sunlight to produce a visible ring? It is beyond our ken, as historians, to guess at what kind of analysis would be involved or to do the maths. Our apologies if our naïve questions are several orders of magnitude out of bounds.

Yours faithfully

Peter James, Marinus Anthony van der Sluijs

University of Pennsylvania Museum of Archaeology and Anthropology,

Philadelphia 2009 November 16.

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