MACARTHUR ASTRONOMICAL SOCIETY Inc.

Journal

PRIME FOCUS

Volume 1 Issue 11 **November 1996**

CONTENTS......

A Very Happy Christmas from The Committee

PRESIDENT'S REPORT

Hello and welcome to all our members and guests. It was great to see the two Carols back. Carol Farrell has kindly donated the use of her property for a camp out at Wilton on 14th December 1996, starting at 5.pm or there abouts.

Tonight we will be enchanted by our own Ragbir Bhathal who is talking to us on his new book 'Australian Astronomers' which will be able to be borrowed from our Society Library from February next year. (It's also available for purchase from the National Library of Australia or Abbey's Bookshop @ $24.95). It is a great read and I will be writing a review on it in a future publication of our Journal.

Last month I believe we had one of our most successful meetings with our very enthusiastic guest speaker Rolando on Cosmology. I found it very informative and entertaining.

Sutherland Astronomical Society hold open nights 2-3 times per year where the public can look through their 16" (400mm) Newtonian which is situated in a dome. Maybe one night we should travel down and make it a Society outing.

President's Report (Cont'd)

There will be no meetings in Dec/Jan due to the Christmas break, but don't forget our Christmas Picnic and Camp Constellation in December. Also, if someone would like to attend the British Astronomical Quiz Night with me in January, please ring me early January for details.

NEXT MEETING:

A few changes in speakers have taken place. Our next meeting on February 17th which will be held in Building 22 Room 5 and will be mostly devoted to **the Annual General Meeting.**

However, we will also be favoured with a talk by Peter Druery about practical tips for telescope viewing and astro-photography - that is, taking photos of stars and nebulae.

Please all attend as we require a good roll up for the election of the various positions and to hear reports.

The positions to be elected are: President; Vice-President; Secretary; Treasurer and three (3) Committee Members. In accordance with our Constitution, nominations for the above positions must be submitted in writing to the Secretary no later than 14 days before the AGM. Nomination forms are available at the November meeting.

SPECIAL NOTE:

I would like to thank each and every member for their contribution toward the society. In one short year we have become known throughout Australia via different publications and have grown to a membership of over 50.

Special thanks must go to Bob for his excellent job on the Journal; Robbie for keeping the books; Dave for filling in at a difficult time as Secretary; Noel Sharpe my invaluable VP and for his contribution to the Journal and star nights; Peter and Eric for there expertise in the field of observing and their excellent tips and help required by the lesser experienced telescope owning members of our society. The society would not have been as relaxing or socially friendly without the valuable and tireless effort from Eric and Claris bringing the Tea and Coffee each week, many thanks; Chris Barnett for the excellent information provided via sheets from the Internet, and finally all of you who helped during the year at writing articles for the Journal or helping out at open day/nights.

FUTURE SPEAKERS:

1. FEBRUARY -- Peter Druery.
2. MARCH --Steve Manos on the Anglo-Australian Telescope.
3. APRIL--Robbie and Chris on Computers in Astronomy
4. MAY--? Jonathan Nally (Sky & Space)
5. JUNE -- Ron Royle on telescope making.
6. JULY -- Phillip Ainsworth on the Solar System (especially Mars).
7. AUGUST-- ?? Melissa Hubert on Comet Hale-Bopp etc;
8. SEPTEMBER--?? Colin Bembrick on Geology of Mars.
9. OCTOBER -- **???? Maybe you.**

There are guest speakers running out of our ears, with some definite starters but dates to be confirmed. Some speakers are also yet to be confirmed, but 1997 looks like a big year for us at MAS.

STAR NIGHT:

At the time of printing Prime Focus, the Star Night at Bringelly on 16th November had yet to happen. (I mentioned it at our last meeting and put it in the Journal). Hopefully, when you are reading this, you will also be hearing verbally how well it went. Next Journal (February) will have a full report on the night.

CHRISTMAS PICNIC:

Christmas is rapidly approaching, and our society is like many having a Christmas Picnic. It will be held at Pembroke Park (on Pembroke Road, Leumeah) on Sunday 1st December, commencing 1pm. It would be great to see as many of our members and family as can attend. Please bring all food and sausages etc; a portable BBQ will be at the park. There are swings and play sets for the children.

CAMP CONSTELLATION:

Its back on, and it is at Carol Farrell's property on 14th December commencing at 6.pm. Come earlier if setting up a scope - you all know who you are. The more telescopes the better chance to see more objects. Some of our more experienced observers will be there to help anyone starting out with there observing with their new or rarely used telescope.

On a dark night like at Wilton, binoculars are particularly good for viewing the Moon etc. I believe it will be out until about 11.pm (Don't quote me.)

Once again we do not want to publicise this Star Night but all members and guests are welcome. Ring me (Phil) to obtain Carol's phone No. to seek directions to her property. I will have a map photocopied for this meeting inserted into the Journal.

If attending, a tent or comfortable car for sleeping would be a good idea and plenty of warm clothing. Some required items are listed below;

1. Jumper, scarf, blanket to wrap oneself in when it gets cold later.
2. Sleeping Bag and Tent if camping.
3. Plenty of snacks and food to eat, bring something for breakfast (long life milk etc).
4. A torch with red cellophane over the end.
5. Some toiletries. Carol has offered her toilet and basin for the various necessities of life.
6. A book or magazine, chair to sit on so one can read by torch light if the clouds arrive.
7. Anything I've forgotten just think what you may need to be comfortable.

A FINAL NOTE-- Thank you all for a very enjoyable year and making my dream of this society a reality. I am sure everyone in this society has enjoyed the year with entertaining talks and star nights. Let's make 1997 bigger and better and aim for 70 plus membership and become one of the biggest in NSW if not Australia.

(Phil Ainsworth - President)

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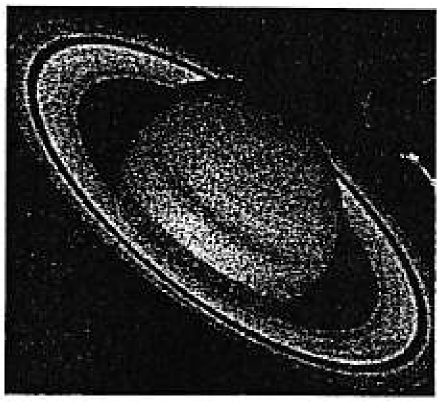


LATEST SOLAR SYSTEM NEWS:

The Russians and the Americans are launching their Mars probes this month. Launch times are in Journal Vol 1 Issue 9 Page 3. More information in the next issue, Vol 2 Issue 1.

In December the U.S. also are launching another craft toward Mars.

Plans for the fast Pluto flyby are really now on definite planning and designing stage. More details next issue.

GALILEO UPDATE--- The Galileo space craft since plunging its small probe into Jupiter has continued to send back unbelievable photos of Jupiter and its four large Moons (See Steve Manos's article on their names.)

The spacecraft has taken pictures 70 times closer with a far greater camera and images.

Some of this remarkable detail has shown us two areas specifically designated as sites to study. These are Uruk Sulcus on Ganymede which is a light coloured, younger terrain and Galileo Regio, a darker, older expanse.

With Voyager, Uruk showed signs of water volcanism with its landscape covered with frozen water which has been belched up from its crust.

Galileo Regio, also on Ganymede and slightly further North, shows wall to wall craters and it is relatively unchanged since the early formation of the solar system.

Uruk has crisscrossed lines and grooves that cut across existing heavily grooved terrain. The icy surface of Ganymede has cooled and expanded the grooves, this now gives scientists a theory that tectonics, not so much Water Volcanism, caused some of the newer regions such as Uruk. Even virtually unchanged Galileo Regio points to some small amount of tectonics. I am sure many other ideas and theories about the moons of Jupiter are being re-evaluated as more data streams into their laps.

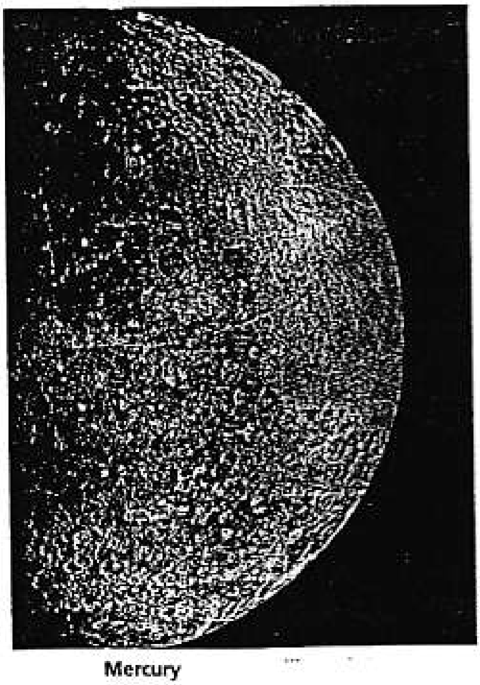
Latest studies have told scientists that like Io, Ganymede may have a molten -iron core. This was discovered when radiation and a magnetic field were detected with an earlier fly past.

Jupiter has not been neglected by the spacecraft and recently it took some stunning pictures of the 300 year old giant anti-cyclonic Red Spot. It also detected patches of Cirrus and white clouds which had ammonia crystals rising out from and condensing into the Jovian atmosphere.

(Phil Ainsworth)

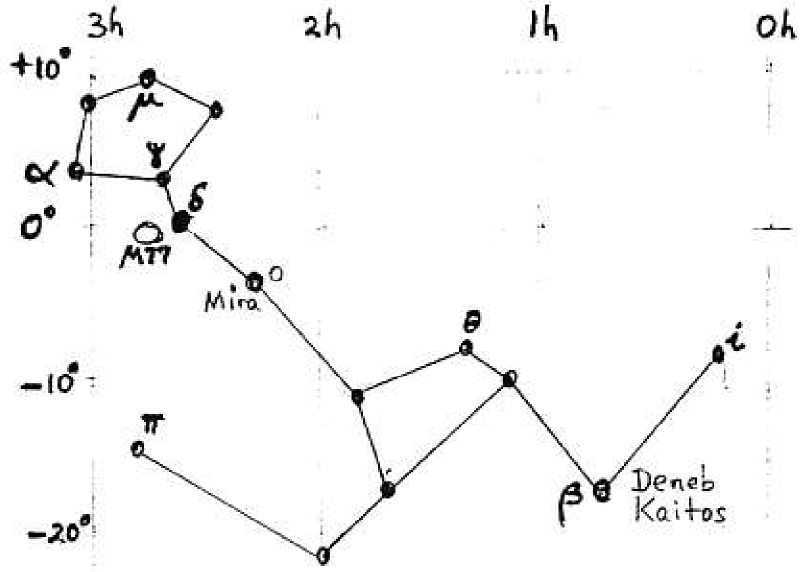
QUICK QUIZ

1. Who orbited the Earth in Apollo 11 ?
2. Who was the last man on the Moon ?
3. Name the spacecraft orbiting Jupiter ?
4. What planet is suspected of life ?
5. What does Prime Focus mean on a Telescope
6. Which is biggest ?
a) Pluto
b) Mercury
c) Titan
d. Ganymede
7. Which Moon around Saturn has a thick atmosphere and what does it mainly consist of ?
8. Who discovered Pluto and is he still alive ?
9. Name the mission and name of Shuttle flight Andy Thomas rode on.
10. Name the best Astronomical Society in Australia ?



Mercury

CETUS - The Whale.



At this time of the year (at 9pm), the constellation Cetus can be found just north of directly overhead. An ideal opportunity for observing.

Mythologically, Cetus represents a sea monster (described as a whale - personally, I think it looks more like Road Runner) that wanted to make a meal of Andromeda but was foiled by Perseus. For the poetically inclined (aren't we all?), Cetus is found adjacent to the constellation Eridanus (the River), apparently basking on its banks (not beached, we hope).

Though not one of the more spectacular constellations (it is fairly large in area but faint), it contains a number of objects worthy of our interest.

α (alpha) Ceti: Also known as Menkar, 'the nose'. This is a giant red star (mag 2.5) about 160 ly away. You can see a blue-white companion (mag 5.6) through binoculars. This is a visual binary only.

β (beta) Ceti: also known as Deneb Kaitos, 'tail of the whale' (or Road Runner's hind knee?). Though dubbed 'beta', at mag 2.0, it is in fact brighter than alpha. It's a yellow giant 62 ly away.

γ (gamma) Ceti: A small telescope with high power may separate the 3.5 mag (yellow) and 7.3 mag (blue) stars that make up this close double. Gamma Cetiis 75 ly away.

o (omicron) Ceti: This is an amazing and well known star - at least to astronomers. It has the honour of being the first variable star to be discovered. In 1596, David Fabricus noted its strange appearances and disappearances. However, its periodicity of variation was not noticed till 1638, at which time Holwarda named it Mira Ceti - 'the wonderful star in Cetus'.
Mira varies between mag 3 and 9. (It has been known to be as bright as mag 2). Its variance period itself varies from 320 to 370 days, with an average of 332 days. During these variations, its diameter varies from 300 to 400 times that of our Sun. It is a Type M Red Giant and is about 250 ly away.

τ (tau) Ceti: In some ways the most interesting member of Cetus. An ordinary Class G (G8) star. A yellow sub dwarf. The eighteenth nearest star to our Sun. 11.8 ly away. Mag 3.5. So what?

Well, all the closer stars are either non-G class or are parts of double systems and so unlikely to have habitable planets. i.e. ***Tau Ceti is the nearest single Sun-like star*** and a prime candidate for SETI. To date, there has been no evidence of planets around it. Is the similarity between SETI and Ceti just a co-incidence? Stay tuned.

M77 (NGC1068): With a 150mm+ scope, you may see this mag 9 face-on spiral galaxy. A radio source Seyfert, it is one of the furthest Messier objects, being about 50 million ly away.

(Bob Bee).

Choosing a Telescope

- An attempt to Help You Resolve a Perennial Problem

by Peter Druery

A common question asked by beginners, (apart from the ubiquitous - which is better - reflector or refractor?) is - how big a telescope do I really need? Does size matter? Now, of course, there are always going to be many considerations here, not the least of which is how big is my wallet! Does it need to be very portable? Do I prefer to observe certain types of objects? Am I interested in trying my hand at astrophotography? Or am I more interested in planetary, deep sky or general observing, and so the list goes on.

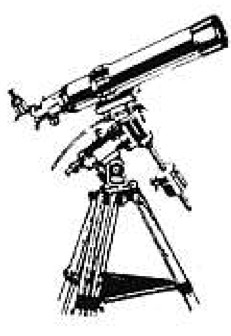
In an ideal world we should select the optimum type of telescope to suit its use. The purists would argue, for example, that a scope which is intended to be used for deep-sky, faint object astrophotography should be large and fast. That is, it should have a short focal length in relation to its aperture. This reduces the exposure times needed for a given object to a minimum. However, if you intend to use the scope as a visual only instrument, particularly for high resolution planetary observing, for example, the opposite is true. A smaller aperture (to decrease the effects of atmospheric seeing), but not too small, and a long (slow in photographic terms) focal ratio.

So, here's the dilemma. What type, size and focal characteristics are the best for you. One thing I would like to stress at this point in our little discussion is that you should resist the initial temptation to jump into the bigger must be better myth. I have come across many people who have invested in the proverbial light bucket only to be dismayed at the extra time and effort which is often required just to set up for an observing session, let alone the dismantling and packing up, especially at 1 or 2 O'clock in the morning. Far better to have a relatively small but high quality instrument that will be used regularly and with a great deal of enjoyment than have a larger telescope gathering dust somewhere in the back of the garage never to see the light of night again!

Nevertheless, it must be admitted that you cannot expect to have a decent astronomical instrument without it having some reasonable aperture. No doubt most people understand the importance of the telescope's ability to gather light. In this regard the telescope should be regarded as a 'collector', similar to a rain gauge. How much light will be collected and allowed to subsequently pass into the observer's eye, or to a photographic film, is thus directly proportional to the surface area of the telescope's objective mirror or lens. If you put two upturned umbrellas out in a rainstorm and one was twice the diameter of the other you would naturally expect the larger umbrella to collect a great deal more water in the same amount of time compared to the smaller umbrella. So too with light. Remember, light may indeed be thought of as having a discreet 'quanta' or particle-like nature (the photon) and at the same time a dual wave-like nature.

Since the amount of light collected, just as it would be for the rainwater, is a function of the total surface area of the collector, this works out to be proportional to the square of the diameter of the mirror or lens. For example, a 20 cm telescope (8") has a surface area (and hence light collecting power) four times that of a 10 cm (4") scope, and yet it is only twice as large. The difference between the light gathering power of an 8 compared to a 16-inch is also the same. However, the differences in cost, as well as other factors take a significant 'quantum leap' also.

So, you can see that, all things being equal, the larger the better - aperture fever strikes again! A 12-inch-aperture will outperform an 8-inch, but *there* is the catch. All things are rarely equal! The cost for instance, the quality of the optics, the effects of increased weight and the subsequent need for heavier-duty and sturdier mounts to avoid the 'shakes', not to mention the increased effects due to the Earth's atmosphere (the larger the aperture the larger the atmospheric column the telescope has to view through and the greater its degrading effects will be).



But there is another aspect of a telescope's ability which must not be overlooked - and this is it's resolving power. But wait, what about magnification? - I hear you say. I have ignored it so far and so should you. A telescope's magnification is meaningless, and it unfortunately is a specification which all too often seems to take first priority with many novices (and some manufacturers too for that matter!) So let's take a closer look at this often misunderstood characteristic by jumping into a little bit of the wave physics associated with light.

By resolving power we mean the ability of an optical instrument to distinguish fine details in an object. For example, if we look at a distant object such as the moon through a telescope, what is the smallest object which we will be able to see clearly on the surface? The angle subtended by this object at the telescope, measured in minutes or seconds of arc, is the *resolving power* of the telescope. You might think that if we want to see smaller objects on the moon, or indeed any other object, all we have to do is to increase the *magnification* of the scope, but this is not so. Once the magnification has been increased to the point where it is the resolving power of the telescope and not of our eye that limits our ability to distinguish features on the moon, then a further increase of magnification simply makes things look bigger but just as blurred as before and we gain nothing. The only way the resolving power of a telescope can be increased is by making the objective lens or mirror larger.

To understand this more clearly, consider, for example, the opaque screen X_1 in *Figure 1.* which has light from a very distant point source of light, for example a star, falling upon it. There is a pinhole of diameter d in the screen and the light falls on the white screen at X_2. Now, instead of seeing a single pin-point of light on the screen we will see a bright spot surrounded by alternate dark and bright rings. This is due to the *diffraction* effects produced by the light waves as they pass the edge of the hole. The hole's edge has the ability to slightly bend the light (diffract it) and these waves begin to *interfere* with the waves passing through the centre of the aperture unhindered.

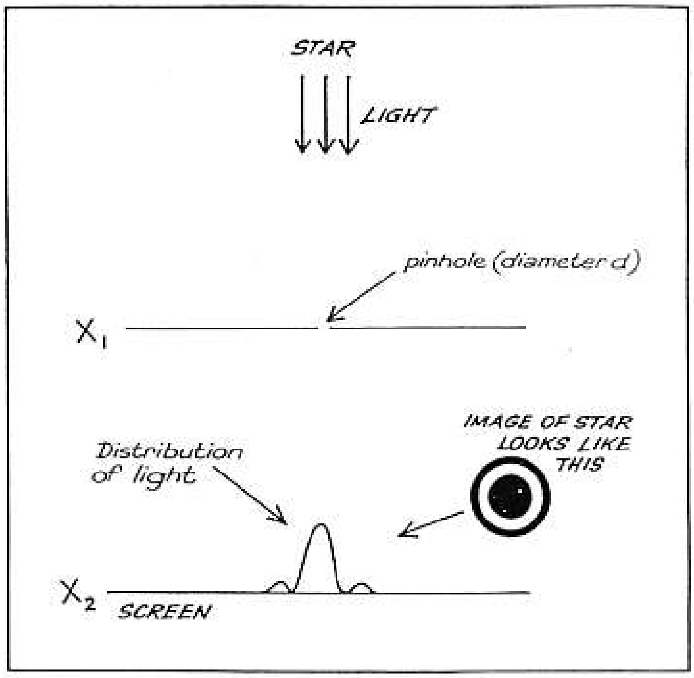


Figure 1. The image of a distant star formed by a pinhole

[You can observe this similar and very interesting effect when water waves enter an opening in a sea-wall or harbour entrance. The wavefronts bend very slightly around the edge and continue on a different pathway as though they were originating from a new point source.]

The appearance of these rings diminish in brightness very rapidly as we go outwards from the bright central spot. It is quite easy to work out the size of these rings. To do this we must work out the path-lengths from every point in the plane of the hole to a particular point on the screen; when all these path-lengths are known we can then find the total resultant light at the point by adding together all the waves with what we call their proper phases.

If you think about this problem you will find that, as in *Figure 1.*, the first dark ring is formed when the path difference from a point on the screen to the extreme edges of the hole is one wave-length, or for the more mathematically inclined

when the wavelength $(\lambda) = d \sin \Theta$

where Θ is the angle subtended by the radius of the first dark ring at the hole, and the screen is assumed to be far from the pinhole. If Θ is small we can put Θ is $\cong \sin \Theta$, and we then get the result,

Angle subtended by radius of the first dark ring is approximately equal to: $\lambda \div d$ *radians*

Choosing a Telescope (Cont'd)

In actual fact this calculation is not exactly correct and for a circular hole involves quite a lot of complex mathematics. However, the exact calculation was made in 1801 by Sir George Airy, the then Director of the Royal Greenwich Observatory, and it turns out that for a circular hole the radius of the first dark ring is slightly larger than we have estimated. Airy showed that for a circular hole the angle subtended by the radius of the first dark ring is $1.22 \times \lambda \div d$.

This result gives us the theoretical limit to the resolving power of any circular aperture; it is simply a question of how large the aperture is in terms of the wave-length of light. It is quite simple to show that it is true for any mirror or lens (or dish in the case of a radio-telescope). Although we can alter the linear size of the image shown in *Figure 1.*, for example by magnification with an eyepiece, we won't alter the *angular* resolving power which is always limited by the size of the hole (aperture) through which light enters the instrument.

Now let's imagine that we are looking at two bright points of light with a scope, for example, a double star, then they will appear as two bright spots surrounded by rings as in *Figure 2.*

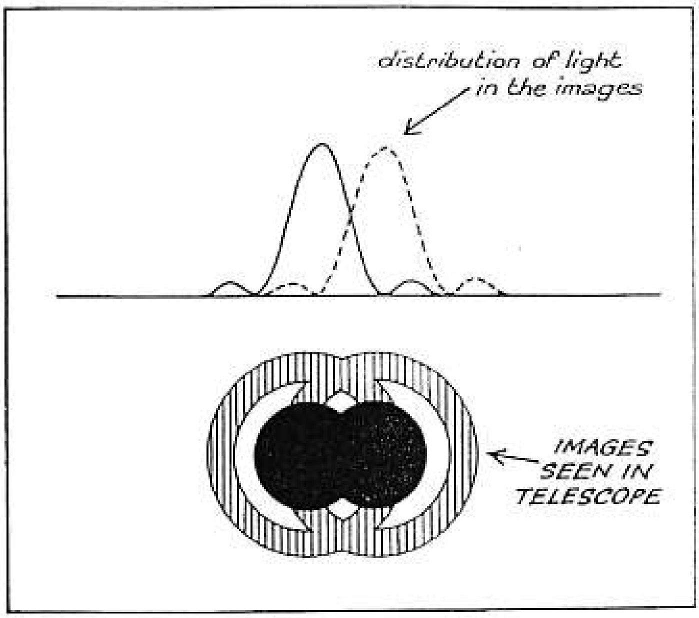
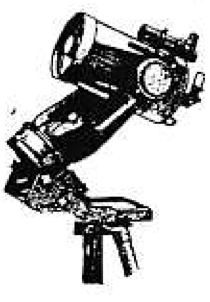


Figure 2. The image of a double star which is just at the limit of resolution.

In practice its actually quite difficult to distinguish them clearly when the bright central spot of one image starts to touch the central spot of the other image. This happens approximately when the angle subtended at the telescope by the two spots, or two stars, is $1.22 \times \lambda \div d$.

To take a specific example, if our telescope has an objective lens with a diameter of 35 mm (a common size for binoculars), and we take the wave-length of light to be 5.6×10^{-4} mm, then the minimum angle between two objects which is distinguishable will be



$$\Theta = \frac{1.22 \times \lambda}{d}$$

$$= \frac{1.22 \times 5.6 \times 10^{-4}}{35} \text{ radians}$$

= 4 seconds of arc.

At the distance of the moon, 4 seconds of arc corresponds to a distance of about 7.6 km (1 second of arc equals about 1.9 km at the moon's distance). So roughly speaking we should be able to discern objects slightly larger than this, say 8 km craters on the moon, with our binoculars. Now, this conclusion assumes, of course, that the binoculars are perfectly made, and that the 'seeing' conditions are perfect; in practice the optics will not be perfect, the atmosphere will degrade the image, and hence the resolving power will probably be considerably worse than we have estimated.

By the way, you will probably come across a slightly simpler version of this formula which looks like this,

$$\text{Resolving Power} = \frac{120}{d}$$

(where the diameter is in mm)

$$= \frac{4.56}{d}$$

(where the diameter is in inches).

This is a little rougher, and is based on a mean average wavelength for light but gives a value which is not too far from correct. You may have heard of this formula, which seems to exist in a variety of forms, as Dawes' limit. Dawes, who was a nineteenth century amateur, devised this calculation to estimate resolving power. It must be remembered that Dawes used a small refractor to establish the relationship, and hence the formula does not translate perfectly to other types and sizes of telescopes. Hence it is not a 'definitive' test of telescope optics. Many high quality instruments routinely outperform the figures!

So you can appreciate that if we want to see objects smaller on the moon, or see double stars which are closer than 4 seconds of arc, we must get a larger telescope, and we must use it at a high altitude to overcome the effects of the atmosphere, or better still put it in orbit like Hubble! Because of the atmosphere it is not possible to reach Dawes' limit on all but exceptional nights. The following table shows how the resolving power increases with the diameter of the instrument but remember this is the theoretical limit.

DIAMETER OF OBJECTIVE	THEORETICAL LIMIT
3 mm (human eye)	40 sec.of arc
7.5 mm (eye - dark adapted)	16
35 mm (binoculars)	3.42
15 cm (6-inch scope)	0.8
20 cm (8-inch scope)	0.6
25 cm (10-inch scope)	0.48
30 cm (12-inch scope)	0.4
500 cm (200-inch scope)	0.024

Choosing a Telescope (Cont'd)

To distinguish objects which are about 1 second of arc in angular size we need at minimum a 6-inch telescope. This will allow us to see quite good detail on some of the planets and to distinguish many double stars. If you go to what was for many years the largest telescope on Earth, the 200-inch Mt. Palomar, its theoretical resolving power is about 0.03 seconds of arc. In principle this is just sufficient to allow us to see the actual outlines of nearby stars. For example, the angle subtended by Betelgeuse is 0.047 seconds of arc and so it should appear as a visible disc. But in practice the Earth's atmosphere nearly always sets the limit and the resolving power of a large telescope is rarely better than about 0.2 seconds of arc.

The maximum diameter that Jupiter reaches from Earth is about 48 seconds of arc. Looking at the table you can see that, with a 6-inch telescope under excellent conditions we should be able to discern details whose size reach approximately a sixtieth of the angular diameter of the planet. Similarly, through an 8-inch scope under the same near perfect conditions we should be able to discern details in the order of an eightieth of the of Jupiter's diameter.

In addition, of course, the brightness of the resultant image seen will be directly related to the diameter of the objective. In the final analysis you can see that it is the diameter which seems to be the essential characteristic of a telescope - it is what essentially determines the instruments capabilities - ALL ELSE BEING EQUAL that is!

One final point worth remembering, telescope optics are often advertised as being 1/8th of a wave or 1/20th of a wave. What does this mean? This represents how far the optical surface deviates away from an ideal surface measured for the middle of the spectrum (usually 555 nm - the green/yellow sodium line). However, the important point is not really how good the individual optical surfaces are but how small the error is in the final wavefront of light emerging from the complete telescope. When light is reflected from a mirror with a surface accuracy of 1/16th of a wave the wavefront error doubles and becomes 1/8th. A telescope design with two mirrors each of which has a 1/8th wave error has an 'accumulated' error of 1/4 of a wave. This figure is the rock bottom for perfect star images. When these errors are calculated correctly, that is, to the correct criterion, we refer to the optics as being diffraction limited. But beware! Most manufacturers almost never specify wavefront error for their scopes, and if they do this is often misleadingly referring to the individual optical surfaces and not the accumulated error.

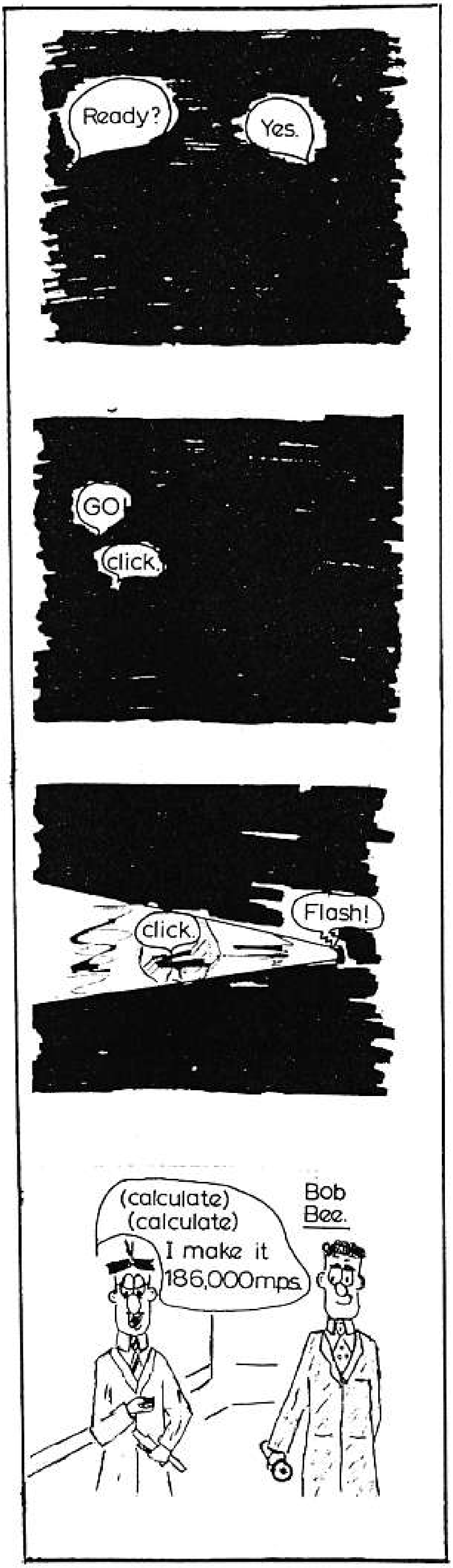
So, I hope this information might help you to some extent if you are thinking of acquiring your first telescope, or indeed if you are dissatisfied with your current scope and are thinking about upgrading in the near future.

Choosing a Telescope (Cont'd)

Maybe I'll see you at a Macarthur field night soon and we can compare optics - you show me yours and I'll show you mine!

Till next time, clear skies, and a very Happy Christmas to everyone - may your stockings be filled with telescopes!

(By Peter Druery)



ET PHONE HOME

ET has got another chance to phone home...or rather Earth. The world's most sensitive search for evidence of intelligence elsewhere in the universe got under way at the 140 foot radio telescope at Green Bank, West Virginia at the end of October, 1996.

Project Phoenix, the privately funded search run by the SETI Institute, California, was here in Australia at the Parkes radio telescope in the first five months of 1995 to closely examine 209 nearby star systems.

It left behind a legacy in the form of the SETI Australia Centre, which was set up at UWS Macarthur by the Faculty of Business & Technology in late 1995 as a result of Dr Bobbie Vaile's involvement with Phoenix and the faculty's first year physics subject based around SETI. The Centre has just completed its first education trial in 12 Sydney high schools using SETI as the educational tool to get into physics, chemistry, biology and astronomy. A second, much larger trial is planned for 1997.

It's the first time Project Phoenix, a direct descendant of the abandoned NASA SETI project, has made in the northern hemisphere and will look at 800 stars from Green Bank. Some of the stars on the list have since been found to have planetary companions.

Phoenix at Green Bank is somewhat fitting. The president of the SETI Institute is Professor Frank Drake who carried out the first ever SETI experiment at this very observatory. Back in 1960 he made a very limited search of two nearby stars, Tau Ceti and Epsilon Eridani. He also created the Drake Equation there - which provides a way of estimating the number of intelligent communicating civilisations in the galaxy - though numbers can only be estimated for most of the factors at the moment.

Today's Phoenix experiment, which monitors 28 million channels simultaneously in two polarizations, is approximately 100 trillion times more sensitive than Drakes first experiment 36 years ago. Phoenix researchers use this capability to step these channels slowly up the radio dial to listen to a total of two billion frequency channels between 1,000 and 3,000 megahertz.

Has anything been found yet? Dr Seth Shostak, Public Programs Scientist with the SETI Institute says that so far ET has been coy...

Meanwhile, the SETI Australia Centre, under the guidance of chairman Dr Ragbir Bhathal, is looking forward to having more than 1,000 high school students involved in its next education trial.

(By Carol Oliver, Science Journalist University of Western Sydney Macarthur)

a detailed look at

Jupiter

part 1

by Steven Manos

Based on their physical properties, the planets in our solar system fall into two categories, the Terrestrial and Jovian planets. The Jovian planets are giant, primitive, liquid worlds, quite different from our own, that have evolved less since their time of formation.

Jupiter is named after the King of the Olympian Gods and is the largest planet in our Solar system. Because of its large size and high albedo of 0.51, Jupiter is a bright planet in the Earth's night sky.

Jupiter's orbit about the Sun has a small eccentricity of 0.0484, semimajor axis of 5.2028 AU, and completes one sidereal orbit in 11.862 earth years.

It has a body rotation period and 9.9249 hours and is tilted on an axis of 3.08°. Jupiter has an equatorial radius of 11.19*Re* and a mass of 318*Me*. These have been determined accurately by observing the orbits and occultations (eclipses) of its moons, by noting the gravitational disturbances it imposes upon passing comets and asteroids, and by Voyager flyby measurements. Jupiter also has a mean density of 1330kg/m3. This low density implies that Jupiter has about the same composition as our Sun of about 75% hydrogen, 24% helium, and 1% other heavier elements (by mass).

The 'disks' of Jupiter show bands of white, blue, red and yellow clouds, which result from the various chemical compounds formed there. These banks change their structure with time, but the Great Red Spot, a large high-pressure storm in Jupiter's atmosphere, has been constantly observed since the nineteenth century. This enormous atmospheric feature measures about 20,000 by 50,000 km. It changes shape, position, and intensity. The cloudy atmosphere reflects light well thus resulting in the planet's high albedo.

The alternating strips of light and dark regions that run parallel to the equator are called zones and belts. Infrared observations show that the zones have lower temperatures than the belts, and because the atmospheric temperature falls at greater altitudes, the zones are higher up than the belts. These differences of temperature imply that the zones mark the rising regions of high pressure and the belts descending regions of low pressure. Occasionally, dark blue, red, brown, and white ovals have appeared against the banded background, lasting as long as one or two years.

From a variety of observations, we know that the Great Red Spot is a few degrees cooler than, and extends about 8km above the surrounding zone.

Infrared spectroscopy has revealed the chemical composition about the clouds. Methane (CH_4) was the first to be identified in 1934. Later, ammonia (NH_3), molecular hydrogen (H_2), and atmospheric helium (He) were found. Voyager also observed acetylene (C_2H_2), ethane (C_2H_6), phosphine (PH_3), water (H_2O), and germane (G_2H_4). A few molecules containing deuterium are also known to be present. An analysis of Voyager's spectroscopic data implies that Jupiter's upper atmosphere contains (by mass) about 78% hydrogen, 20% helium, and 2% all other *a detailed look at Jupiter (cont'd)*

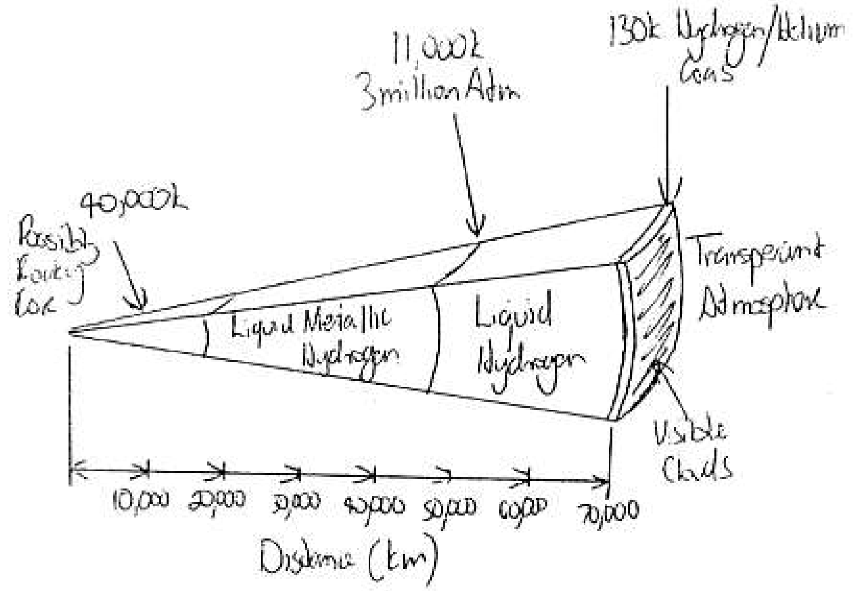
elements, a composition esentially the same as the Sun's. Most of this material exists as molecules.

At the tops of the zones, the temperature is about 130K, making the visible clouds most likely ammonia ice crystals. Then, according to one model, which describes three separate cloud layers making up the upper atmosphere, lies a layer of ammonia hydrosulphide (NH_4HS) clouds. Below these float ammonia vapor and water ice clouds.

The colours of the Great Red Spot and other atmospheric features probably result from chemical reactions between major and trace molecules, with photoionization and dissociation driving the reactions to make hydrocarbons that provide the colouration.

An interesting fact about Jupiter is that Jupiter radiates into space about twice as much more energy as it receives from the Sun. The total internal excess power amounts to about 4×10^{17} W (roughly equal to the energy input). The internal heat is probably left over from Jupiter's formation.

Models of Jupiter show that the density, temperature, and the pressure increase inward (as expected from the hydrostatic equlibrium), so much that hydrogen exists in a liquid state. At a pressure of about 3 million atm (Earth atmospheres), the hydrogen is sqeezed so tightly that the molecules are separated into protons and electrons that freely move around and can conduct electricity. This state is called metallic hydrogen.



Structure of Jupiter

Now, for all of you who would like to know a little about the 'maths' of Jupiter.

The equation of hydrostatic equlibrium can be applied to the interior of a stable planet, one which is not contracting nor expanding. This condition then requires that the pressure increases as one goes deeper into a planet's interior (because greater weight has to be supported). We can use this equation to roughly estimate the central pressure of Jupiter (or any other planet for that matter);

G, the constant of gravitation; $G = 6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$

p; the density of the planet; In Jupiter's case, about 1300kg/m3

π, pi; 3.141592654. .

R; the radius of the planet, in metres; In Jupiters case about 70,000,000m, or 7×10^7m

$$P_c = (2/3)\pi G\langle p\rangle^2 R^2$$

$$P_c = (2/3) \times 3.141 \times (6.67 \times 10^{-11})\langle p\rangle^2 R^2$$

$$P_c = (1.396 \times 10^{-10})\ \langle p\rangle^2 R^2$$

$$P_c = (1.396 \times 10^{-10})(1300)^2(7 \times 10^7)^2$$

$$P_c = (1.396 \times 10^{-10})(8.3 \times 10^{21})$$

$$P_c = 1.2 \times 10^{12}\ \mathrm{Pa} \quad \text{(Pa=Pascal)}$$

$$P_c = 1.2 \times 10^7\ \mathrm{atm} \quad (1\ \text{atmosphere} = 10^5\ \mathrm{Pa})$$

And that makes the central pressure of Jupiter 12,000,000 atm!

Most of Jupiter is hydrogen, and most of that hydrogen is liquid, quite a contrast to Earth and other terrestrial planets. The flow of heat outward from the core drives the convective circulation of the atmosphere. The rapid rotation of the planet creates a large Coriolis acceleration that produces the beautiful banded atmosphere.

Jupiter's rings

Jupiter's ring system, discovered by Voyager 1, are essentially transparent, less than 30km thick. They are most visible when viewed edge-on. The particles contained within the rings are only about 3μm in diameter, and on the basis of their infrared properties, they are most likely rocky material.

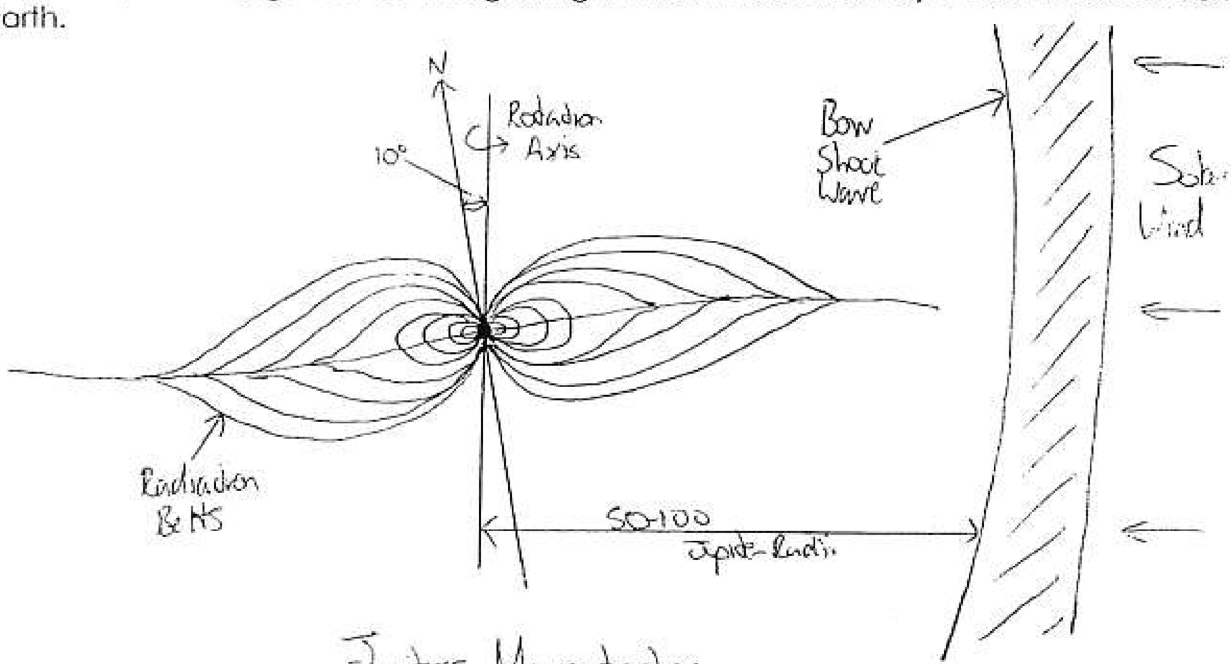
Images show the rings have a definite structure. The brightest, outermost part is 800km wide and lies about 128,500km from Jupiter's centre. Within it is a broader ring which is 6000km wide, and within that ring lies a faint sheet of material that extends from 119,000km out from Jupiter's centre down to the planet's cloudtops.

Jupiter's magnetic field

Jupiter's magnetic axis is inclined at 9.6° to Jupiter's rotation axis. From radio observations here on Earth, Jupiter exhibits radio emissions that have been linked to a magnetic field of about 4×10^{-4} T at the surface of the planet. In comparison, Earth has a surface field of 0.31×10^{-4} T. This strong magnetic field arises from a dynamo mechanism in the rapidly rotating liquid core of metallic hydrogen. The planet radiates wavelengths from 3 to 75cm, nonthermally. This decimetre radiation (1 decimeter = 10^{-1}m) is 'synchrontron radiation', produced by relativistic electrons spiralling at near the speed of light in Jupiter's radiation belts trapped by Jupiter's magnetic field.

- Radio interferometry measurements and the Voyager missions reveal radiation belts similar to the Earth's Van Allen radiation belts, which extend beyond 3 Jovian radii at the magnetic equator. This intense field creates around Jupiter a huge magnetosphere that deflects the solar *a detailed look at Jupiter (cont'd)*

wind. Scientists have observed sporadic radio bursts at decametre wavelengths (1 decametre = 10m), and they were connected with the transit of Jupiter. Later, some radiation was found associated with the position of Io relative to Jupiter's magnetic axis. This emission is most likely generated in and above Jupiter's ionosphere on magnetic field lines that thread to Io along a magnetic flux tube. A strong burst generates approximately 10^{11} J, where in comparison, here on Earth a lightning bolt generates about 10^{5} J. These radio bursts are most likely generated by 'superbolts' of lightning. Some Voyager images from the nightside of Jupiter show bright regions in the atmosphere that may be lightning. Violent updrafts and turbulence in Jupiter's atmosphere probably generates this lightning in much the same way a thunderstorms do here on Earth.



Jupiters Magnetosphere

If Jupiter's magnetosphere was optically visible, it would stretch 2° across the sky - four times larger than the Sun or Moon. Jupiter's magnetosphere falls into three distinct zones.

inner magnetosphere - here the magnetic field generated by currents within the planet dominate. This zone extends out about $6R_J$

middle magnetosphere - here, equatorial azimuthal currents control the field configuration. This zone extends out about $30R_J$ to $50R_J$

outer magnetosphere - the geometry of this depends on the sunward or nightside orientation. The sunside field acts as a buffer zone that expands and contracts in relation to the solar wind's intensity. The nightside shows a long magnetic tail, about $400R_J$ in diameter and a few AU in length.

When Voyager took pictures of Jupiters 'nightside' it showed polar 'aurorae' for the first time. The photographs showed that they occured in at least three different layers, at 700, 1400, and 2300km above the cloud tops. Presumably, these aurorae take place for the same reason they do here on Earth; the excitation of the upper atmosphere by energetic charged particles pouring in near the north and south magnetic poles. Interestingly enough, some of these particles were shown to flow in from Io, and are trapped by Jupiter's megnetic field, the others are simply solar wind particles.

In Part 2 of 'a detailed look at Jupiter', we'll be looking at Jupiter's satellites . . .

"A ROYAL COMMISSION" INTO WHO MURDERED THE DINOSAURS - PART 2.

(By Noel Sharpe - Crime Correspondent)

To recap on Evidence 'A' already presented to the Commission by Sherlock Holmes a Court that the dinosaurs met with foul play: See Part 1.

Sherlock was in desperate need of follow-up evidence. After long hours of soul searching, what was needed was a walk. Inspiration came courtesy of a close encounter. Holmes happened to glance into a nearby lounge room window and saw Richard Dreyfus piling tons of dirt and rock into an incredible mountain-like mound. Holmes sensed that it was somehow important, so he arranged for the local nursery to deliver 18 tonnes of topsoil into Building 22, Room 5 of the Royal Commission.

The next morning when Holmes made his appearance he was stunned into silence. The nursery had been creative and decorated the mound of dirt with pine trees, conifers and bush rock, making it look like a giant forest.

The delegation erupted with calls for Holmes to be sacked and charged with contempt. Sherlock was devastated and defeated.

Holmes didn't know what he was doing, but he felt obsessed and was hoping an explanation would come at the last minute.

As what always happens, inspiration arrives in one's darkest hours and Holmes is a brilliant genius. With one giant yell that silenced all his critics, Sherlock yelled... Tunguska!

Camera were rolling, photos and notes taken as Holmes delivered Evidence 'B':

An explosive force measuring 10 megatons of TNT devastated the Tunguska River Valley in Siberia in 1908.

This explosion was caused by an invader to our planet, a meteor 50 metres in diameter, which created a compression wave when it entered our atmosphere and exploded just overhead of the Tunguska forest, destroying hundreds of square kilometres. This evidence is sound and irrefutable.

Such destructive power is immense compared with the very feeble 'A' bombs of 1945.

Holmes was on a high and, feeling very satisfied, adjourned himself to morning tea secure in the knowledge that Evidence 'B'"was tucked under his belt and all contempt charges were dismissed.

When leaving the lecture room, he accidentally kicked a large boulder at the base of the Tunguska mound. Homes looked downward and realised that his shoe was broken and would need to see the 'Shoemaker" down by the 'Levy' bank. Whilst there, a discussion ensued regarding the damage caused by the lump of rock. Holmes realised that a much larger rock could cause more damage and imagined a likely scenario as follows:

If a planet - say Jupiter - was invaded by a comet, what would happen? The comet would enter at a speed of 300km/sec and upon superheating the surrounding atmosphere, would reach critical mass and explode. Such energy would send enormous amounts of material skywards and would crash back down, blanketing the planet.

Sherlock entered the above as Evidence 'C' and said that a comet or asteroid killed the dinosaurs. The Head Justice of the Commission, the Right Honourable Doubting Thomas, challenged the evidence and demanded that Holmes provide proof positive of his assumptions.

Holmes always holds an ace up his sleeve and countered with... "Proof, of course I have proof in the form of evidence 'D'.

Discover Evidence 'D' in the conclusion of 'Royal Commission..." in the next issue of Prime Focus.

A Personal Observation of M42

This object, of course, has got to be perhaps the best known deep-sky object in the heavens, an object so majestic that you cannot help but return to it many times. However, no matter how familiar this old friend is, it still has the power, not only to leave you in awe, but sometimes leave you with the feeling that you have just seen it for the very first time.

Through my little 4" maksutov at a power of 33x it is a magnificent and inspiring wide-field view. This is such a large object! The appearance is especially good when Orion is high in the sky and viewed from a relatively dark site. In some ways it begins to take on an unfamiliar 'mottled' appearance when seen under such a dark sky.

At this relatively low power there are many other stars in the field and this gives you the sensation that you are observing the object from some point out in space rather than from terra-firma (well, if you use you imagination a little!). In my 8" Celestron, with the F6.3 reducer corrector in place, the brightness of the object is astounding.

Using a 40 mm eyepiece yielding approximately 32x you begin to get the tantalizing impression of a very faint greenish glow and perhaps the faintest hint of some sort of pastel colour (slightly pinkish and perhaps some yellow to me). This seems to be more definite if you look intensely and directly at the central core area surrounding the 'Trapezium' stars, rather than with 'averted' vision. The overall colour effect is of course extremely faint, but this nebula is bright enough to be able to start turning your retina's cones on, and I reckon I can just sense it! The green tinge is definitely there.

Interestingly, one of my very young sons, Dylan, is given the opportunity to view this celestial wonder of stellar birth - literally a stellar nursery. I ask him what he sees (with no prompting or coaching). I am amazed by what his very young eyes apparently see. He tells me: *"green Daddy, green! A big green cloud, with wings and stars!"*

I'm left wondering if he really can see this colour and, after consulting some of my ophthalmic textbooks, I come to the conclusion that he quite possibly does. All this gets me thinking; I wonder how many of you - particularly our really young members, can also perceive any hint of colour in this ultra-bright emission nebula? Perhaps you could let me know of your own observations.

I push the magnification up to 88x using my favourite 23 mm wide angle eyepiece and removing the reducer corrector so that the scope now works at F10. This gives a very different view by increasing the relative darkness of the background sky and improving the overall contrast. The convolutions and extensive dark rifts and lanes in the nebula, particularly towards its outer perimeter pop into easy view, and I find that I enjoy a great deal of time just slowly moving the scope around the full extent of the object enjoying a tour of its more subtle features.

Bumping the power up still further using a 2x barlow and adding a light pollution (LPR) filter an incredible wealth of subtle but yet intricate detail can be seen - like extensive tendrils. The four central trapezium stars stand out superbly.

I leave M42 and begin to search the region not very far away surrounding 'Zeta' Orionis to see if I can catch a hint of the horsehead while I've got the LPR filter on. I get a very vague impression but finally convince myself after ten minutes or so that I'm imagining it. I head back to M42 for another 'fix'. Superlatives escape me!

- Peter Druery

"WRINKLES IN TIME"

If last month's speaker, Rolando Demichiel sparked your imagination about cosmology, the Big Bang and all that, "Wrinkles in Time" by George Smoot may be a good follow-up reading.

It is more of an account of a personal journey through the field of cosmology than a text or reference book.

While covering all the technical concepts of cosmology for those interested in the details, it is also 'a good read'.

If you want some further description of the time frame of the Big Bang (from 10^{-43} sec to the present), quarks, the plasma soup, the inflation period, open versus closed (or flat) universes, space-time, quantum physics, background radiation, dark matter... it's all there.

Yes, it's all there...but explained in the context of George Smoot's personal career as a budding graduate (who started study to be a medical doctor) who branched into cosmology.

Get the inside story of academics bursting to be the first with a new frontier expanding discovery. Share his joys and nightmares with high altitude balloons and the U2 spy plane as instrument platforms and the COBE (Cosmic Background Explorer) program.

All this in an endeavour to discover if the Big Bang did happen, how did the universe come to be the way we see it now? What caused the clumping of matter into galaxies, clusters, superclusters and megaclusters?

Read how he and his colleagues discovered the answer with 'wrinkles in time'.

Often amusing, always interesting - I recommend it for those the least bit interested in Life, the Universe...and everything.
('Wrinkles In Time' is available at Campbelltown City Library - 523.12 SMO)

(Bob Bee)

M42 - The Great Orion Nebula.
Photo by Peter Druery, using a C8 at F10, 20 minute exposure.