Reflections

Journal of the Northern Sydney Astronomical Society Inc.

Volume 26 Number 2 **April-July 2015**

In this issue

President's Message

Hello all Members

Looking back on previous "messages" I see a few recurring themes, including the NAG, what we can do for our new members to encourage them to become long term and the need for a Secretary.

Sometimes it can be a plus when things don't change.
The New Astronomers Group (NAG, for the uninitiated) for instance, is about to commence its third program in the new, improved format, and the signs are positive once again.
Not surprisingly, this program has become a valuable source of members for NSAS, and that leads on to one of those ongoing points: what can we do better to encourage our new members to become active within NSAS?
As a committee we are always discussing this point, but in the end it is largely a matter of engagement and friendship.
I believe we are OK at this, but there is always room for improvement – so the need is for all of us to get in there and do our bit.

Our NSAS speakers have refined their topics and those attending can expect a really well balanced series of presentations and papers covering a mass of interesting subjects for the "new astronomer".
Many will remember my early comments on becoming President, on the need to spread the admin load rather than relying on a very small number.
We have achieved some degree of change and Lawrie Webb's taking on the Observations role and bringing on board several Members to help out, is an excellent example.
And you know where I am going here – yes, that's right – SECRETARY!
Come on people – there has to be a few out there who are willing to help out.
Give me a quiet call if you like and I will give you a feel for what it's all about and how you could make a contribution, with help from other members.
And, as a bonus, you get to attend Committee Meetings!

Moving on, we had our first and very enjoyable "second BBQ" at the college, with everything up to the usual standards.
I'm thinking we could force feed our new members with a rib-eye steak (nice work John) and a glass of wine at these events and make a good time mandatory.
All we need to do is get them along.

The big news at the moment is the new observing site.
At the first viewing evening at Mona Vale Road, I understand the results were, without exaggeration, not far short of Hubble!
And to top it off, there were perhaps (at least?) 500 people there to bear witness to the values of this top site.
Perhaps I am a little over the top, but the message is, Observations is perhaps the most fundamental function of an astronomy group and NSAS has just been given a big lift.
Get in there and experience it.
Not having a telescope is not a concern, all our observer members are delighted to show new members and visitors around the night sky.
Just turn up. All you need to bring is your interest.
Check the web site for details of the location.

Last point – we have, unfortunately, had to give both Stephen Hawking and Brian Cox a rather terse message not to keep chasing us to do their respective presentations.
We have said that Bob Fuller has arranged an ongoing program of quality speakers, and that if we have a sudden vacancy we may give them a call.
Sometimes you just have to be cruel to be kind, don't you think?
See you soon

Bruce Retallick

Well, well, well,

It hasn't happened since the April edition last year but, for this issue, I'm very happy to give you an eight-page Reflections!

Actually, I'm being a bit cheeky because, as you may have noticed, this a combined April/July edition; going overseas for sometime I would not have been able to prepare the July one so I decided to extend the deadline for the April one and merge them into one.

And, you will be judge, but I think the result is great: two excellent articles by our now regular contributors Josephine Lindquist and David Wallace and Mathias Sorg, our resident astrophotographer, is starting what should prove to be a very informative series on... astrophotography.

Even if you are not tempted to try your hand at this hobby, you may have wondered what was going on behind all those wonderful amateur photographs we can see in magazines or on the web. So, now you are going to get all the answers and, as you will discover in the following installments, there is a lot of work involved but it seems to be particularly addictive and, to use an old commercial, 'Once you've popped, you can't stop!'

By the way, don't stop sending your contributions in.

Cheerio,

Jean-Luc Gaubicher

Calendar

General Meetings:	May 19^{th}	Speaker: Bob Fuller - Sky stories of the Dreaming
	June 16^{th}	Speaker: Kyler Kuehn (AAO) - Star Bugs: Observing the heavens with a hundred eyes
	July 21^{st}	Speaker: Angel Lopez-Sanchez (AAO)- Astronomy and Light
	July 21^{st}	Speaker: Andy Green (AAO) - Bigger than Big: how do we know how big
NAG Meetings:	4th Tuesday of each month	
Observing Nights:	Consult NSAS' web site at http://nsas.org.au/observing/	
Deadline:	Please send your contributions to the next issue of Reflections in time to reach the editor **before September 15^{th}** to nsas.editor@ozemail.com.au	

Space Junk - The curse of Human Complacency

Currently there are about 1,000 operational satellites orbiting the earth. These provide us with long-distance communications, earth observation (e.g. weather, land usage), navigation (GPS) and of course intelligence gathering (i.e. spy satellites).

Satellites occupy various orbits, from low-earth orbit (100 to 400km altitude where they complete an orbit in 40 minutes or so) to geostationary orbit (36,000 km up where they complete an orbit in 24 hours).
Satellites (at least the low earth orbiting ones) can be seen as fast moving points of light just after dusk or just before dawn.

This article deals with all the other stuff us humans have put into earth orbit.
Space junk includes defunct satellites and the rocket boosters used to put them into orbit.
It also includes small objects such as paint flecks, slag from solid fuel rocket motors, solidified droplets of coolant and the occasional discarded glove.

Figure 1 gives a graphical representation on the distribution of space junk.
The geostationary orbit is indicated by a large circle of space junk around the earth's equator.
On this graph, the size of the space junk is not to scale. In reality, from this vantage point in space, the space junk would be too small to see.

When a satellite has reached the end of its life (typically within 7 years of launch), it can either be de-orbited (i.e. returned to earth) or left in orbit.
Typically, satellites other than those in low-earth orbit do not carry enough fuel to be able to be de-orbited. Hence most satellites are left in orbit after the end of their useful lives.

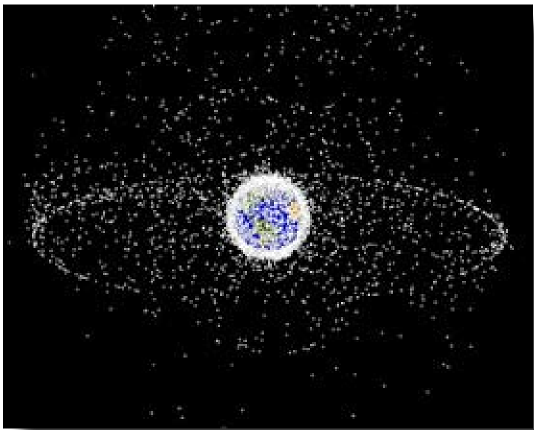

Figure 1: Space debris seen from outside geosynchronous orbit. NASA Orbital Debris Program Office, photo gallery

The orbit of satellites eventually decays due to drag with the upper earth atmosphere.
The upper earth atmosphere is very thin, but it is dense enough to slow the satellites down.
For a satellite in low-earth orbit, this may take several months or years. For a satellite in geostationary orbit, this may take a very long time (tens of thousands of years).

Some satellites like the International Space Station or the Hubble Space Telescope, are periodically boosted back into a higher orbit to counter the drag of the upper atmosphere.

Figure 2: This large storage cylinder crashed to earth on remote Woorlba station 230 km east of Norseman WA. http://www.space.com/21092-skylab-space-station-debris-photos.html

When a satellite eventually returns to earth, it poses little danger to people.
Most of the satellite will be burnt up on re-entry. Those pieces that survive will most likely land in the ocean or over an uninhabited area.
This was the case with the American Skylab space station that crashed in Western Australia in 1979.
A piece of Skylab is shown in Figure 2. This now resides in the Esperance Museum in Western Australia.

The exception to this is nuclear powered satellites.
Both the United States and the Soviet Union have launched nuclear powered satellites.
As these were low-earth orbiting satellites and to stop radioactive material return to earth in the short term, their nuclear core was boosted into high earth orbit at the end of their life.
Unfortunately, the Soviet Kosmos 954 satellite, along with its nuclear core containing 50kg of uranium, crashed into northern Canada in 1978.

The amount of space junk has been steadily increasing. This is shown graphically in Figure 3.

The graph shows the increase of space junk as a result of the Chinese testing their anti-satellite weapon in 2007

on the Fengyun-1C satellite.
The interceptor (kinetic kill vehicle) destroyed the satellite with a high-velocity impact. This resulted in a large amount of debris adding to the growing space junk problem.

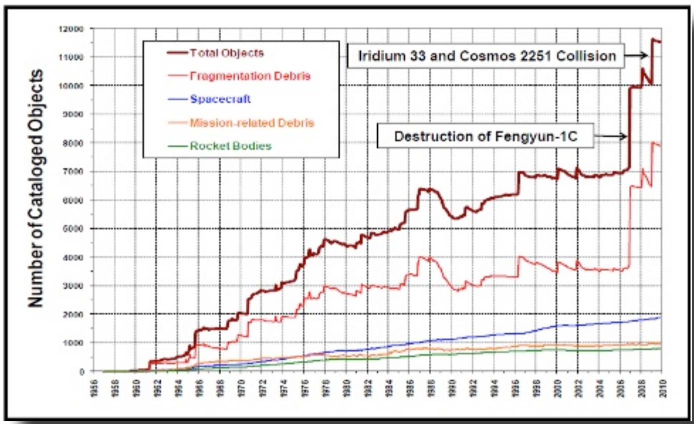

Figure 3: Growth of the catalogued low earth orbit space object population NASA Orbital Debris Quarterly News, Volume 14 Issue 2 April 2010

In response to the Chinese anti-satellite test, the United States conducted their own anti-satellite missile test in 2008.
The target satellite, USA-193, was destroyed. Luckily, due to the low-earth orbit of the satellite, no long-term space junk was generated.
It was always assumed that space is really vast and space junk was really small, so the change of collision was considered negligible.
However, because they are in orbit, they have many more chances for their paths to cross other satellite pathes.
The increasing amount of space junk has resulted in an increased risk of damage to satellites.
There is a concern that collisions between satellites and space junk could results in the destruction of the satellite.
This would in turn increase the amount of space junk, which would result in an increased chance of other satellites being destroyed. This is called the Kessler Syndrome.
The collision of the Iridium 33 satellite with the defunct Kosmos 2251 satellite in 2009 is a sign that this could happen.

So the question is what we can do about space junk?
We can add shielding to satellites to protect them from damage. This would work for small pieces of space junk but not for large ones.
Removing space junk from orbit say by using lasers is not a practical option.
The best way is not to produce so much space junk in the first place.
This would involve reducing the number of satellites, extending the lifetime of the satellites we currently have and de-orbiting satellites when they are no longer required.
Most of all, refrain from producing anti-satellite weapons.
This is a big ask for humans.

David Wallace

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http://en.wikipedia.org/wiki/Space_debris
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http://en.wikipedia.org/wiki/Kessler_syndrome
http://www.esperancemuseum.com.au/skylab/
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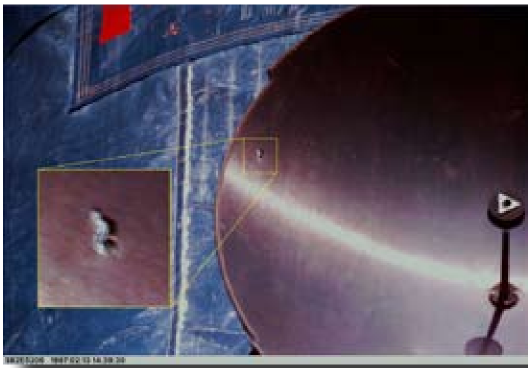


Figure 4: An impact that completely penetrated the antenna dish of the Hubble Space Telescope NASA, Orbital Debris Program Office

March 2015 General Meeting

Guest speaker, Prof. Wayne Orchison, being thanked by Vice-President Gordon Ogborne for his talk on John Grigg

Josephine Lindquist belatedly receiving her own Geoff Welch prize for 2014, as well as a second one on behalf of Graham Nicholson.

Pictures by Ken Schofield.

Tide up with the Sun and the Moon

Just how connected are our tides with the Sun and the Moon?

My fascination with tides began when my family moved to Gosford from inland NSW in the mid-1960's.

I saw then for the first time the effects of a king tide when the tidal creek running alongside the (now called) Central Coast Highway between Gosford and Erina would rise and cover the road each January.

The fishermen continued to fish but for other locals, our family included, this was an exciting event and we'd head to the spot just to look and ponder the science that explained this phenomenon.

The potential difficulties in accessing the local beaches crossed our teenage minds as well.

Low tide and high tide at Manly

So, what are tides?

Tides are the rise and fall of sea levels caused by the combined effects of gravitational forces exerted by the Moon and the Sun and by the rotation of the Earth[1].

High tides:

It is the Moon that has the greatest effect on the tides.

On the side of Earth facing the Moon, the Moon's gravitational force pulls the Earth's oceans towards it creating a bulge.

At the same time on the opposite side of Earth the Moon's gravitational force is weaker, which causes another bulge to occur.

These are the high tides and consecutive high tides are on average 12 hours 25 minutes apart (half the time of the Moon's apparent revolution of the Earth).

Low tides:

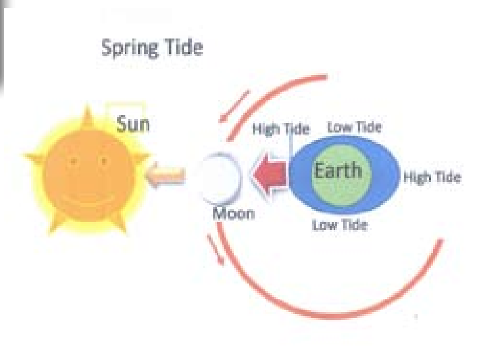
As the Moon orbits Earth the bulges move with it. In between, the Earth's oceans are depleted thereby creating the low tides.

What causes the differences in tidal heights during the month?

Spring Tides:

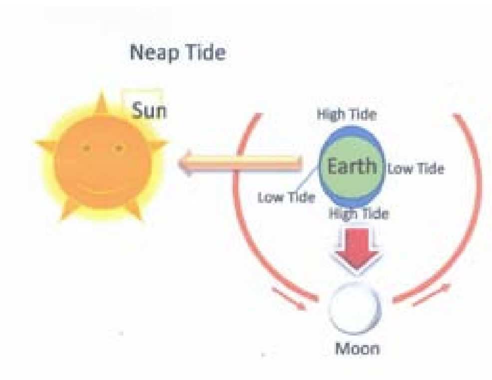
The Sun's tidal forces are only about half as strong as those of the Moon due to the Sun's greater distance from Earth. However, during the lunar monthly cycle the Moon aligns twice with the Sun, once at New Moon when the Moon and the Sun are in the same direction (the Moon is said to be in conjunction) and again at Full Moon, when they are in opposite directions, the Moon is then said to be in opposition

During these alignments there is a consequent increase in gravitational force resulting in tides with the largest range (i.e. largest difference in height between high and low waters). These tides are known as spring tides.



Neap Tides:

During the Moon's 1st and 3rd quarters, the Sun and the Moon are at right-angles and the overall gravitational effect is diminished. Consequently the tidal range is small. These are known as neap tides.



"Spring" and "Neap" tides probably aren't found in everyday conversation. More people, however, have come across the term "king" tides, but what are they?

King tides:

This is a colloquial term to describe a seasonal high tide often combined with onshore winds, or any exceptionally high tide, in some cases due to a storm surge[2]. Conversely, the low tides occurring at this time are the very lowest tides.

The term can be used to describe spring tide storm surges occurring during cyclones (e.g. Cyclone Marcia that hit the Queensland coast on 20 February, 2015) but, more commonly, it is used to describe a particularly high spring tide that occurs once a year due to the proximity of the Earth to the Sun.

The Earth moves around the Sun in an elliptic orbit that takes just over 365 days to complete. The Sun's gravitational force is greatest when the Earth is at perihelion (closest to the Sun) in early January, and least when the Earth is at aphelion (furthest from the Sun) in early July. So, spring tides are enhanced when the Earth is at perihelion, around 2 January each year creating a king-sized tide[3].

Do tides always behave the same way everywhere?

From the information given so far we might expect that there would always be two tidal cycles each day comprising of two highs and two lows. That's not always so.

Tides are commonly semi-diurnal (two cycles per day) or diurnal (one tidal cycle per day).

Semi-diurnal tidal patterns:

The semi-diurnal tides feature two patterns. The first one occurs when the height of the two high waters are about the same each lunar day, and likewise for the two low waters.

When tides were first studied along the North Atlantic coastline this was the pattern observed and therefore considered to be the norm.

When explorers went further afield they discovered that in many locations the two high waters or the two low waters were of significantly different heights and/or times.

This is now known as "diurnal inequality", or "mixed tide" and it occurs around the coasts of Australia, the west coast of America and many other coastal locations.

Diurnal tidal pattern:

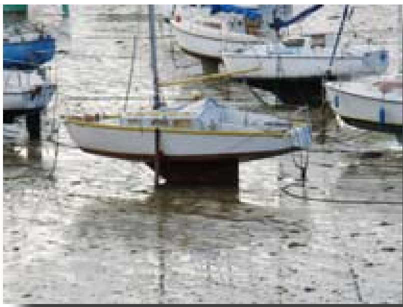
A diurnal tide is one where the interval between consecutive high water tides is 24 hours.

These occur in areas such as the Gulf of Mexico, the Java Sea and the South China Sea.

At some locations there may be only one

observable daily tide, but this could simply be the higher of two daily tides under a diurnal inequality pattern, where the second and lower tide does not appreciably raise the level of the water and so is not apparent as a tide. This is what happens at Port Lincoln in South Australia[4].

What are the causes of these differences in patterns?
Basically it is due to the Earth's land masses and ocean basins.
To quote from a National Oceanic and Atmospheric Administration article: "*If the Earth were a perfect sphere without large continents, all areas on the planet would experience two equally proportioned high and low tides every lunar day.*
The large continents on the planet, however, block the westward passage of the tidal bulges as the Earth rotates. Unable to move freely around the globe these tides establish complex patterns within each ocean basin that often differ greatly from tidal patterns of adjacent ocean basins or other regions of the same ocean basin"[5].
What goes into predicting tides?
Predicting tides is a very complex task.
Up to 40 components go into this at any one location to create a table of variations due to local conditions.
Apart from the celestial components already mentioned, tidal analysis includes coastal characteristics such as the shape of the shoreline and ocean floor, under water bathymetry (measurement of ocean depth), and coastal morphology's effects on tidal flow.



Low tide at Saint-Quay-Portrieux (France) where tidal range can be in as much as 10 m.

Over many years of careful observations and keeping detailed records, tide predictions at individual locations have become reasonably accurate, but tide timetables still carry a caveat to cover the unexpected.

And what is the latest on Gosford's king tides?
An upgrade of the Central Coast Highway has stopped the annual flooding that fascinated me all those years ago.
However, king tides in the area still create local interest and news for state and local newspapers[6].
On 2 January this year the king tide at Woy Woy caused the local ferry wharf to disappear under water, streets to flood and, of all things, anglers to get their feet wet!
Nice to know the interest continues.

Josephine Lindquist

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2. *http://www.bom.gov.au*
3. *http://en.Wikipedia.com/wiki/King_tide*
4. *http://www.abs.gov.au/ (1301.0 - Year Book Australia, 1938, "The Tides of Australia").*
5. *http://oceanservice.noaa.gov/education/kits/tides/tides07_cycles.html*
6. *http://newslocal.newspaperdirect.com/epaper/viewer.aspx (Central Coast Express Advocate Gosford)*

Pictures and diagrams by the Author

Tide up Post-Script

A rare celestial event in the northern hemisphere on Friday March 20, 2015 caused the first "supertides" of the millennium over the following two days along the French Atlantic Coast, in the English Channel, the North Sea and in Canada's Bay of Fundy.

On that day:
- The new Moon was at perigee (the Moon was closest to Earth in its monthly elliptic orbit);
- There was a solar eclipse in the northern hemisphere (visible as a partial eclipse across Iceland, Greenland, Europe, UK, North Africa, western and eastern Asia, and a total eclipse across the Danish archipelago of Faroe Islands, and also across the Norwegian island group of Svalbard), and
- March 20 marked the northern hemisphere spring equinox (a day in which the periods of daylight and night are equal or close to equal depending on where you are on Earth, and when the Sun is directly over the equator).

The resulting gravitational pull of the Moon and the Sun created tides not seen for many years. Heralded as the 'tide of the century', this positioning of celestial bodies actually occurs every 18 years.

At Mont-Saint-Michel on the Normandy Coast of France, 30,000 people watched as the spring tide, enhanced by the straight-line positioning of the Sun, the Moon and the Earth during the eclipse, and also by the position of the Sun over the equator during the equinox, rose more than 14m, all but surrounding the famous island.
Average tides in this area measure 8.7m.

The low tide was as impressive as the high tide as the sea receded 15 km from the coast.
Hundreds of people took the opportunity to walk on the mudflats where beaches and rocks were revealed for the first time since 1997.
But they couldn't overstay their exploration; when the tide turned, it came in faster than a person can run.

The next northern hemisphere "supertide" resulting from this celestial phenomenon will be in March 2033

Josephine Lindquist.

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1. *http://www.abc.net.au/news/2015-03-22/tide-of-a-century-turns-mont-saint-michel-into-an/6339178*
2. *http://www.smh.com.au/world/full-moon-and-solar-eclipse-combine-for-tide-of-the-century-in-northern-france-20150321-1m4qc0.html*

Astrophotography 101 - 1st Part

Getting started - Into the deep end

What is it all about?
Aside being an amazing hobby that puts complex theory to a practical use, Astrophotography is lots of fun!
There is an endless amount of new things to learn and you can "see" things you just can't otherwise and you begin to realise just how much is hidden in the depth of the night sky.
The pleasure of being able to say "I did that" has immense power.
I for myself have adored the stunning images coming to us from the Hubble Space Telescope for a large part of my life; however, these are not my pictures.
Whilst plenty of people are using these images from NASA to show and tell the story of our universe, I wanted to see for myself how far an amateur astronomer can go. And boy (!), am I far away from what's possible... more about this later.

Astrophotography is very versatile and can be done in many different ways from many if not most locations in the world.
Light pollution is a nuisance these days but is in no means a show-stopper for the aspiring astro-imager.
I have only just recently achieved great outcomes by imaging through my telescope from my balcony, looking all the way down South-East where the Sydney CBD provides a 24/7 cone of light at its best.
Using special filters and various other techniques, you can still achieve a lot, no matter where you live.
So I'd say... let's explore this a little further together.
Don't restrict your imagination. Go where your mind wants to go and venture into an excitingly challenging and rewarding hobby for many years to come!

Planetary vs Deep Sky

Never has Astrophotography been as versatile as it is today. Never has it been a more feasible hobby for a broader audience than these days.
It's the era of Digital SLR's, Webcams and decreasing price tags on dedicated Astro-Cams. Telescopes are available in any price range from a couple hundred dollars to many tens of thousands.
Be aware though: This hobby can get extremely expensive...

Planetary Imaging

It can however be extremely cheap for a start and make you perfectly happy at that.
It can be as easy as holding your mobile phone camera onto your eyepiece to project an image to the sensor.
I've seen stunning results in planetary imaging with new generation mobile phones.
Whilst this is a start, you might want to consider one further step ahead: a perfectly common webcam, connected to your PC via USB connection. This simple device available for as little as about $30, second hand even cheaper, can transform any telescope into a planetary imager.
This shot here was taken with an 8" Newtonian Telescope on an Equatorial Mount using a Barlow lens to magnify the image and a Philips SPC900NC webcam, one of the oldest but best webcams as it holds a light sensitive CCD imaging sensor instead of a CMOS chip that is more common these days.

All it took was to frame Saturn in the camera view, which is way more challenging than it sounds... more on this later, focus properly and capture a video with a software fit for the purpose.
I personally use wxAstroCapture.
The video should be a few thousand frames long and the settings you use really matter so it will take a bit of asking around as well as fiddling about to get it right.
It can be a while until you master this technique.
Also, given that the larger planets appearance is rather seasonal through the year and that seeing conditions are rarely really good this part of the hobby alone will keep you busy for a long while.


Saturn

Deep Sky Imaging

With this starts a whole new part of this exciting hobby.
I for myself was drawn to this in a flash.
Things like faint nebulae and even fainter galaxies have always drawn my attention like a magnet.
The famous Hubble image "Pillars of Creation" is one of my all time favourites and the reason I'm so invested in this hobby.
Hence the equipment I bought is optimised for Deep Sky photography.

So what does that mean? Deep Sky?
It means really, really far away objects that are nowhere near the bright things you can easily spot in the sky.
The Moon is the brightest thing you'll see in the night sky, directly followed by some of the planets of our solar system.
Then there are the brightest stars that we can observe.
Then there are countless stars that appear dimmer to our eyes... we move out, further into the vastness of space.
There you'll find some bright Deep Sky Objects (DSO's) that are still visible to the naked eye, barely, such as the Andromeda Galaxy, the Great Orion Nebula, the Magellanic Clouds and globular clusters.
Further out there are very faint things like reflection nebulae, myriads of galaxies, planetary nebulae. Not even binoculars help you here, for these you need a telescope.
And even then there are limits!

Now, I've never done much visual observing hence I'd say I'm really not very good at it.
The limits that I have can easily be stretched by people who regularly observe the night sky visually, have very dark adapted eyes and simply know their way around the heavens...
There is however only one way to see the majority of these very faint hidden beauties amongst the darkness: long exposure photography!
And now that is what we'll spend a moment on.

Equipment considerations

What do you need for this?

1. A mount that is capable of tracking the movement of the sky
2. A telescope (or camera lens) that is fit for the purpose
3. A camera that suits your ambitions as to what objects you're planning to image
4. A guiding setup suitable for the above.

I can only scratch the surface here but plan to go into more detail in later articles. This hobby is complicated and even after 4 very active years I'm still trying to master what I'm doing.
Regarding #1: Ideally you'd have an equatorial mount.
This simply is the best and most effective way to have your telescope follow the movement of the sky around the poles and makes guiding and very long exposures possible.
As for #2: This is a very rough definition as a lot of telescopes, or camera lenses in the case of wide-field photography, are fit for the purpose.
In general I would say for DSO's you should consider shorter focal length and wide aperture telescopes such as Newtonians.

Mine is 8” aperture and 1m focal length. This gives me an *f*/5 focal ratio, which describes the “speed” of the telescope.
The lower the number behind the *f*/, the faster the telescope gathers light.
Hence small *f*/ numbers about *f*/5 and below are considered fast and higher numbers especially *f*/10 and above are considered slow.
Without going through a lot of theory here, this basically means that slow telescopes are best for planetary imaging, they allow for higher magnification and that is what you want for such bright and small targets.

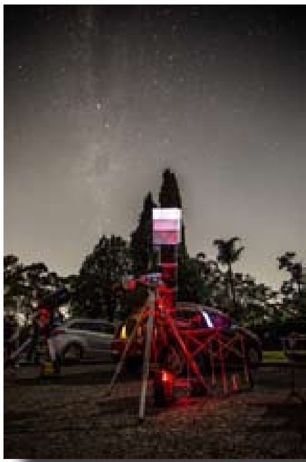
M31 - The Andromeda Galaxy

Fast telescopes are best for Deep Sky Objects as they allow for the most light to hit your eyepiece/camera sensor in a given amount of time.
DSOs are very faint and when talking about long exposures this could be anywhere between a few seconds up to 30 minutes for a single exposure.
There really only are practical limits to going beyond that.
Compare this to daytime photography when exposures are typically very short i.e. a fraction of a second.
I usually take exposures between 2 and 5 minutes for a variety of reasons but I take a lot of them so that I can stack these images together via computer software afterwards.
Again, this process is rather complicated and I can only touch on it in this article.

On to #3: This is a complicated one and your choice mainly depends on what you want to do, can handle and are able/willing to afford.
The choice between camera models can make a huge difference in terms of what you can achieve, but also what you need to spend on it.
Here’s a rough summary:
Digital Single-Lens Reflex cameras (DSLRs) are widely used in astrophotography these days and meant a real breakthrough for most striving astronomers.
They are based on large size CMOS sensors and can be used very efficiently for imaging Deep Sky Objects.
The biggest benefit is the price tag. DSLRs cost anything between $200 and $5000. They are versatile and can be used for daytime photography as well (as long as not modified for night time only).
The biggest drawback is the noise these cameras build up when taking very long exposures. They are not temperature regulated, which makes it very hard and time consuming to collect needed calibration frames, especially dark frames, in order to reduce the noise during stacking afterwards.
Webcams, out-of-the-box as well as modified versions
These are mainly for planetary imaging (where they excel above most other cameras) but can also be modified for long exposure DSO photography. This however takes advanced skills in modifying and to an extent, using them later.
Dedicated Astro CCDs, the holy grail of astrophotography!
These cameras are purpose built and cost between a few hundred and ten of thousands of dollars.
They are low noise by definition and more expensive models include strong cooling functions. This means that noise due to the sensor heating up with long exposures is reduced down to a minimum.
Albeit cooling is one of the greatest benefits, the biggest advantage probably is the CCD sensor these cameras are equipped with.
CCDs are much more sensitive to light than CMOS chips and I heard that they can have the light gathering capability as high as ten times of a regular CMOS chip.
They come in monochrome and One Shot Colour (OSC) models and whilst OSCs are easy and more comfortable to use, the monochrome versions excel if you combine them with a filter wheel and a set of colour filters so that you can individually capture the luminance and the red, green and blue channels for the colour pattern.

M42- The Great Orion Nebula

#4 is actually much simpler than I personally ever thought.
Guiding is in my opinion one of the key success factors for long exposure photography
Even if your polar alignment isn’t spot on, guiding will overcome minor errors and help the mount to stay on track sufficiently for long exposures of many minutes.
Here are a few key things to be aware of:
An equatorial mount needs to be polar aligned, so that it can track across the sky.
This means that the axis of the scope is perfectly aligned with the rotational axis of the planet it’s based on (aka Earth).
This can be done via an in-built polar scope but I’ve never managed to get this right as for us in the southern hemisphere, Polaris Australis is way too dim to be seen in the polar scope.
There are many alternative means of achieving sufficient polar alignment out of which I’ve gotten most comfortable with a method called “Drift Alignment”.



My set-up

In short, in this method you observe a star at two specific points in the sky and observe their “drifts” in your viewfinder. You then slowly correct the declination and right ascension axis as required in order to minimise the drift.
This will get you close enough to being polar aligned from where the guide scope can “take over” and help correct any residual tracking errors.
Once sufficiently polar aligned, you need to attach a guide scope with a guide camera to your main imaging scope.
This can be as simple as my solution, which is an Orion 50mm mini guide scope and a Orion Starshoot Guide camera. This is basically a small finder scope with a webcam-like camera attached.
The camera shows you a field of view with available guide stars on the computer screen and after running a calibration routine, it will send guiding instructions directly to the telescope mount. As simple as that!
There are numerous challenges with this though but we won’t have time to get into these right now.

I’ll come back to and discuss more thoroughly Polar Alignment, Calibration Frames, Image Stacking and Post Processing in the next edition of this Astrophotography column and give you a few specific tips and tricks

Until then, clear skies!

Mathias Sorg

Picture of the set-up by Murray Wilkinson
All other pictures by the Author

Computing the orbital elements of a comet

If you did not attend our March General meeting, you certainly missed out on a very interesting talk by Professor Wayne Orchiston.
Prof. Orchiston, from the National Astronomical Research Institute of Thailand (NARIT) and who is the editor of the Journal of Astronomical History and Heritage, recounted the life of John Grigg, a famous Kiwi astronomer and comet hunter of the early 1900s who is credited for the discovery or co-discovery of 3 comets.

While describing the problems Grigg encountered when he reported his discoveries, Prof. Orchiston remarked that in order to calculate the orbital elements of a comet, all you need are, in theory, 3 observations of this comet.
This aroused my curiosity: how come, having 3 positions in the sky (3 right ascensions, α, and 3 declinations, δ) you can determine the orbit of a comet?

First we have to remember that an orbit is always a conic section: an ellipse, a parabola or a hyperbola.
In this stub of an article, as they say in Wikipedia, we will limit ourselves to the case of an elliptical orbit.
An ellipse can be defined as being the set of points such that the sum of the distance to 2 fixed points (the focal points or foci) is constant.

We know from Kepler that one of the focal point is at the centre of the Sun so we only need two elements to determine the ellipse described by our comet:

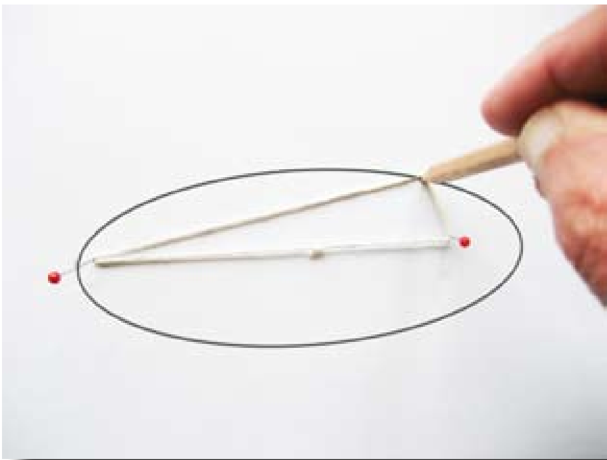
- The semi major axis *a*
- The eccentricity *e*

But... as in most cases the orbit is not coplanar with the ecliptic we need four more elements to determine it:

- The inclination *i*
- The longitude of the ascending node Ω
- The argument of perihelion ω
- The time of perihelion passage T

The inclination *i*, that is the angle between the plane of the comet's orbit and the plane of the ecliptic.
The longitude of the ascending node Ω determines the point where the comet's orbit crosses the ecliptic and the argument of perihelion ω determines the angle between the ascending node and the perihelion.
And, finally, we need the time T.
Phew!
So back to our problem, we have 3 observed positions in the sky at 3 instants in time, it should be possible to calculate the six orbital elements with the help of Kepler's second law.

But, don't ask me how...
No, really!
When I embarked on this attempt I told myself that, if it was done a couple of centuries ago, it might not be that difficult and, to cut a long story short, it does not actually require a thorough understanding of Mathematics, just basic trigonometry and vector calculus.



How to draw an ellipse using 2 pins, a piece of string and a pen

However it involves a great number of steps and, in the most detailed paper I found, it takes 32 pages!
Just out of sheer curiosity and to have an idea of what's involved go to http://astrowww.phys.uvic.ca/~tatum/celmechs/celm13.pdf
As they write in their concluding remarks "*Anyone who has done the considerable work of following this chapter in detail is now capable of determining the elements of an elliptic orbit from three observations, if the orbit is an ellipse and if indeed elliptical elements can be obtained from the observations (which is not always the case)*."

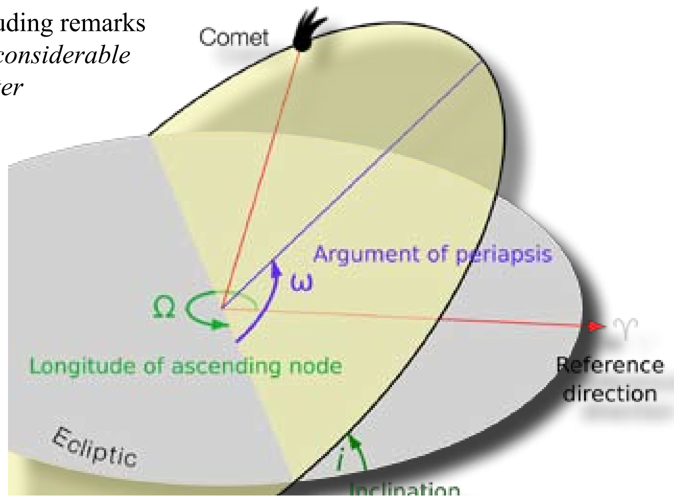
Imagine the stress these poor comet hunters must be under: you spot a comet, check that it is not one that has been already discovered, make 3 observations over a period of time long enough for them to be valid, try and calculate a rough estimates of the orbital elements so that your astronomer colleagues can find it and confirm your discovery and send all that to the Central Bureau for Astronomical Telegrams hoping that nobody else discovered "your" comet and reported it before you did.

I assume that, nowadays, there are some dedicated applications that would do all these calculations but remember, up to the middle of last century, all these calculations had to be made with pen and paper. I tried my hand at it, but gave up after a few pages.

And wait, that's not the end of it, once the rough orbital elements have been computed, they have to be refined as new observations are made and taking into account planetary perturbations and the such.
At least now, our poor comet hunter is no longer on his own, he can expect the collaboration of other fellow astronomers and, hopefully, this comet will be named after him for the posterity.

Jean-Luc Gaubicher

Reference: http://astrowww.phys.uvic.ca/~tatum/celmechs/celm13.pdf
Photo by the Author
Diagram from http://fr.wikipedia.org/wiki/Orbite#/media/File:Orbite.png modified by the Author



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