ASTRONOMICAL SOCIETY

Reflections

Journal of the Northern Sydney Astronomical Society Inc.

Volume 21 Number 2 April 2010

As you can see, this issue of Reflections is thinner than usual: a lack of contributions has forced us to trim it down to six pages. I hope we won't have to cut it down to one page! The long autumn and winter evenings should give you the time needed to write something for our forthcoming issues.

Anyway, in this edition you will find the second installment of Bob Roeth's most intriguing article on space collisions.

Also a short essay on diffraction that some may find a bit too short but this is a multifaceted concept that could cover pages and the aim of this Back to Basics series is to try and simplify such complex issues.

And, finally, a short report on last month Star Party at Mount White and our first Astronomy Picture of the Quarter!

I sincerely hope you will appreciate your magazine and that you will be inspired enough to put pen to paper, or fingers to keyboard, for some future contribution.

Cheerio,

Jean-Luc Gaubicher

In this issue

President's Message

NSAS is nearly half-way through its current year and all our programs continue to be popular and attended, with the possible exception of Observing, which continues to have bad luck regarding clear skies. As discussed in last Reflections, there will be more Dark Sky events, either at Mount White or even further away from Sydney, and new arrangements with North Turramurra Golf Club mean that we can now have short-notice observing any day of the week as long as one of the Observing officers is available. This way we should be able to take advantage of weeknights and weekends away from the usual two weekends of the dark moon. We also have permission now to have Sausage Sizzles at NTGC and the Committee will be planning these during the winter observing months.

The Theory Group continues with "Understanding the Universe". The course is such that newcomers can join in any time and not really miss the plot.

The New Astronomers Group, run by Roy Jordan, continues apace and, by the time you have read this, should be starting a new group of New Astronomers into understanding their telescopes and the tricks of observing.

Since Christmas, we've had about an even number of resignations and new members and our membership stands at just under sixty. There are a few members who have not renewed and are uncontactable so we can assume they will leave the membership roster soon.

In regards to payment of membership, a resolution regarding membership and payment of membership fees is being prepared for a vote at the April General Meeting, and will be circulated at least 21 days before. The essence is that the membership will receive renewal forms in September, membership renewal will be past due 2 months after the October Annual General Meeting and after that members who have not paid will receive a written notice of their status in arrears and, if the fees are not paid within 14 days, the Committee may chose to expel the member from the Society. In case you haven't attended a General Meeting for the last few months, the situation leading to this proposal to change the Model Constitution, which only allows for resignation of members when they are financial, is that too much of the Committee's time is being spent chasing past due membership fees, and often the member doesn't have the courtesy to advise of his or her resignation. In the meantime, that member has the same rights and liabilities than financial members.

The next months should bring some limited outreach activities by the Society, in accordance with our intention to limit this somewhat this year. NSAS will support the Macquarie Open Night on 24 April and early discussions with St Ignatius regarding a Star Party at St Ignatius this winter have started. The speaker program is already filled up to August with a group of excellent speakers from Macquarie Uni and CSIRO. There may also be a volunteer program to assist St Ignatius in getting the Cooke Telescope back up and running, as they have received some funding for this.

Finally, Jean-Luc Gaubicher, who publishes Reflections, has had a difficult time with this issue, with very little membership support in the form of articles. If you have even the slightest interest in a particular astronomy-related subject and would like to write an article, it would be welcomed for the next issue, and please, no "cut and paste" articles, due to intellectual property issues.

In the meantime, don't hesitate to contact me or the Committee about anything that you would like to see the Society do in the future.

Best regards,

Bob Fuller

Calendar

General Meetings:	April 20th	Guest Speaker: Ray Norris on the The Australian SKA Pathfinder
	May 18th	Guest Speaker: Minnie Nao on The Evolution of Galaxies
	June 15th	Guest Speaker: George Hobbs on a subject to be advised
NAG Meetings:	April 27th	
	May 25th	
	June 22nd	
Theory Group Meetings:	April 13th	
	May 11th	
	June 8th	
Observation Nights:	April 9th / April 16th	
	May 14th / May 21st	
	June 11th / June 18th	

Deadline: Please send your contributions to the July issue of Reflections in time to reach the editor **before June 15th**

Back to Basics: diffraction and astronomy

How easy would astronomy be if the image of a star were a point! But, at best, the image of a star is a diffraction disk.

Diffraction is a phenomenon that occurs when a wave encounters a small obstacle. It can be described as the bending of the wave around this obstacle.

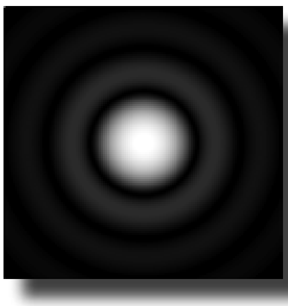
All waves are subject to diffraction: sound waves, water waves, light waves and more generally all electromagnetic waves.

In everyday life, diffraction is what makes it possible for you to hear an orchestra even if your seat is behind a pillar: you cannot see the orchestra but the sound waves diffract around the pillar and you can hear the music without any trouble. Of course, in this case, the multiple reflections on the walls also play an important role.

It is also what makes a harbour choppy even when protected by a jetty and what allows long-wave radio stations to be heard in every nooks and corners of the Earth.

Because light waves diffract when passing through the aperture of a telescope, diffraction is a most important phenomenon in astronomy as it limits the resolving power and therefore the sharpness of any telescope.

Diffraction of a beam of light through a circular aperture results in the light not being focused to a point but rather spread out in a circular pattern that consists of a diffuse central disk, called the Airy disk, surrounded by fainter and fainter rings.



Diffraction disk as generated by a computer

The angular diameter θ of the Airy disk is given by the following equation: $\theta=2.44\lambda/d$

where λ is the wavelength and d the diameter of the lens or mirror aperture of the telescope.

As you can see, the angular resolution of a telescope is proportional to the wavelength and inversely proportional to the aperture.

Let's take an example: if we observe in visible light with an average wavelength of 510nm (or 510 10^{-9}m) with a 20 cm aperture telescope the angular diameter of the Airy disk will be 2.44*510 10^{-9}/0.2 = 6222 10^{-9} radian or approximately 1.28".

Now, another important notion is the Rayleigh Criterion.

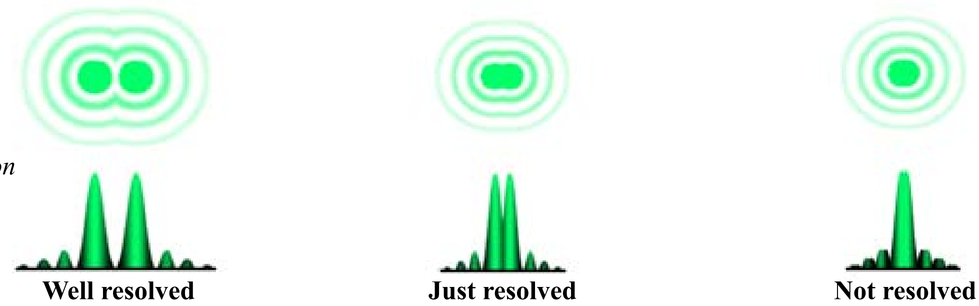
John William Strutt, 3rd Baron Rayleigh (12 November 1842 – 30 June 1919) was an English physicist who, amongst numerous other things, studied the diffraction of light waves and defined what is now known as the Rayleigh Criterion: two adjacent points are just resolved when the centres of their Airy patterns are separated by a minimum angle equal to half the angular diameter θ of the central disks.

In our case, that means that the theoretical angular resolution of the scope is 0.64".

As a matter of comparison, the theoretical angular resolution for a human eye with a 5mm pupil is 25" and for a 10m telescope is 0.013"; another cause for the rampant disease known as aperture fever!

However, the Rayleigh Criterion is based on observation and is somewhat arbitrary. Also, the formula $\theta=2.44\lambda/d$ is valid for 1 aperture/lens/mirror and all scopes have at least 2 lenses/mirrors, not to mention spiders and central obstruction and, in real life, the resolution of a scope is limited by numerous external factors such seeing and turbulences, which means that you'll never be able to reach the theoretical angular resolution of your scope.

Jean-Luc Gaubicher



Airy Patterns of 2 close stars
Images by Michael W. Davidson (Florida State University)

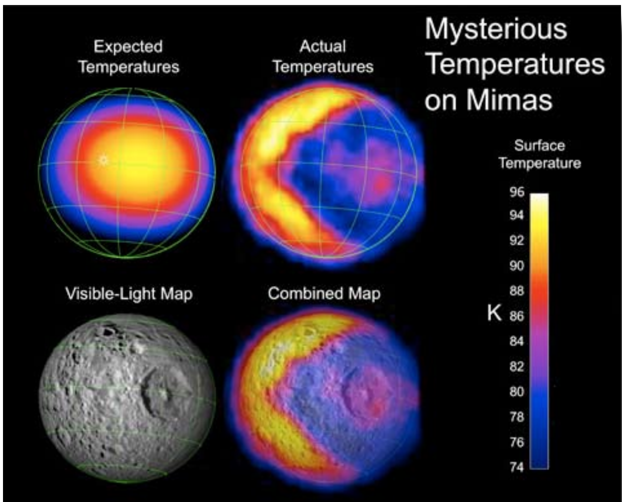
Astronomy Picture of the Quarter

If you wish to submit your own astronomical images for publication send a medium-res JEPG copy to nsas.editor@ozemail.com.au
Please provide all relevant details such date, camera, scope, mount, exposure time...

New map reveals Pac-Man on Mimas

The highest-resolution-yet temperature map of Saturn's icy moon Mimas obtained by Cassini spacecraft reveal surprising patterns on the surface of the small moon, including unexpected hot regions that resemble 'Pac-Man' eating a dot, and striking bands of light and dark in crater walls.

Cassini collected the data on Feb. 13, during its closest flyby of the moon. Scientists working with the composite infrared spectrometer that mapped Mimas' temperatures expected smoothly varying temperatures peaking in the early afternoon near the equator. Instead, the warmest region was in the morning, along one edge of the moon's disk, making a sharply defined Pac-Man shape, with temperatures around 92 K (-181°C). The rest of the moon was much colder, around 77 K (-196°C). A smaller warm spot, the dot in Pac-Man's mouth, showed up around Herschel, with a temperature around 84 K (-189°C).



The warm spot around Herschel crater makes sense because its tall walls (about 5 km high) can trap heat inside the crater. But scientists were completely baffled by the sharp, V-shaped pattern.

It is suspected the temperatures are revealing differences in texture on the surface and maybe something like the difference between old, dense snow and freshly fallen powder.

The pattern may appear because of the way the surface of Mimas ages. Over time, the moon's surface appears to accumulate a thin veil of silicate minerals or carbon-rich particles, possibly because of meteor dust falling onto the moon, or impurities already embedded in surface ice.

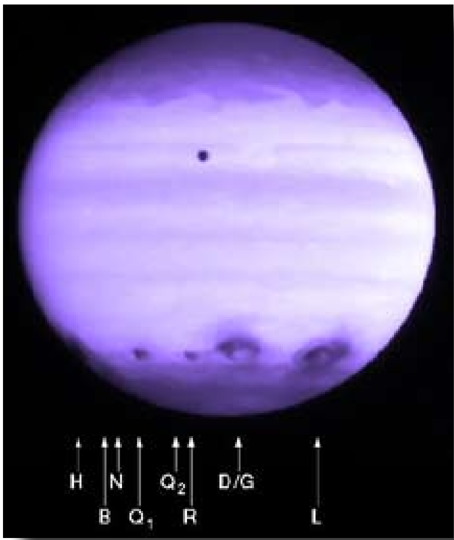
As the sun's rays and the vacuum of space evaporate the brighter ice, the darker material is left behind. Gravity pulls the dark material down the crater walls, exposing fresh ice underneath. Although similar effects are seen on other moons of Saturn, the visibility of these contrasts on a moon continually re-paved with small particles from the E ring helps scientists estimate rates of change on other satellites.

More information and images are available at http://saturn.jpl.nasa.gov

Collisions, collisions! Part 2

Nature has some tricks up her sleeve that might have an effect on the situation. One of these tricks was seen in action just a few years ago.
A comet known as Shoemaker–Levy 9 was expected to turn on a surprising lightshow so every possible large telescope on Earth or in Space was turned on Jupiter. From the time of the comet's discovery, its orbital parameters were regularly upgraded and studied to calculate where it had been before discovery.
The most likely explanation is that on a previous pass near Jupiter, the original comet passed so close to the giant planet that it was initially pulled into an unstable loop orbit around it and then thrown out again. During this unusual manoeuvre, the greater gravitational pull on the near side of the comet teared the comet apart or separated the bits if it was a loose group travelling cheek-by-jowl.
In either case, the orbital paths of the bits spread out a little as do the individual pellets from a shotgun blast. The closest bits were submitted to the greatest gravitational attraction so they were pulled inwards most and speeded up as more of their gravitational potential energy transferred into kinetic energy. The most distant pieces were pulled in least and, relative to the others, moved in less and slowed down minimally as very little of their gravitational energy was transformed into kinetic potential energy.
The result of this was that the comet bits appeared to Earth-bound observers to be strung out in a line. The images from space also showed the bits strung out in linear fashion. Calculations predicted that the next time they came by Jupiter, ground-based and orbiting telescopes would witness the first ever spectacle of a space collision – in fact about twenty quite noticeable collisions - as they speared into Jupiter's upper atmosphere over the space of about six earth days. The calculations on the times of arrival were quite accurate. The visible scars from the collisions with Jupiter's atmosphere were only temporary - a few months - which is quite unlike the scars that have been inflicted on hard surfaces like Mercury, Venus, our Moon or even on Earth's land masses.

Ultraviolet image taken by the Wide Field Camera of the Hubble Space Telescope at a wavelength of 2550 Angstroms. The most recent impactor is fragment R which is below the center of Jupiter (third dark spot from the right). This photo was taken on July 21, about 2.5 hours after R's impact.
Jupiter's moon Io is the dark spot just above the center of the planet.
Credit: HST Comet Team



It has been known for several years that the Sun pulls close comets into its atmosphere. The space package on SOHO – hovering around L1 - picks them up quite easily. Jupiter's huge mass, about one thousandth of the Sun's mass, has been theorised as the cause of such effects as long term comets changing to short-term comets or the reverse.
A more recent discovery by an Australian amateur of another scar in Jupiter's atmosphere is forcing astronomers to wonder just how many comets are being pulled into Jupiter's atmosphere. The Hubble telescope had been going through various set-up operations after its major refurbishment in May 2009 when the announcement of the collision was made. Immediately, steps were taken to turn Hubble on to Jupiter and the plume of the entry was imaged. This image promptly appeared on the web.

This is a NASA's Hubble Space Telescope image of the impact sites of fragments "D" and "G".
The large feature was created by the impact of comet fragment "G" which impacted Jupiter on July 18, 1994. The smaller feature to the left was created on July 17, by the impact of comet fragment "D".
Credit: HST Comet Team

What can we conclude from the Shoemaker-Levy 9 observations?
A space body with some weak zones can be broken by differential gravitational forces into smaller parts as it passes a much heavier body. The bits can spread out somewhat like the pellets from a shotgun and if they eventually impact the heavy body, they will land at different times and in different places. There would be more but smaller impacts. All three of these landing conditions would decrease the effect of an asteroid meeting the Earth. Could Nature do a copycat act with Apophis and Earth?

Another trick from Nature's sleeve was long-hidden though predicted by George Darwin, son of the Charles Darwin who suggested a theory of biological evolution. George was investigating a theoretical situation in which two bodies are orbiting in the same plane about a much heavier central body but with one orbit being just a bit smaller then the other. The background for this investigation had begun in 1609 AD when Johannes Kepler showed that for any planet orbiting the Sun, the orbital shape would be an ellipse. A few years later, he showed that a planet closer to the Sun would complete an orbit in less time than a planet further from the Sun and that there was a mathematical relationship between orbit sizes and lap times: the angular velocity of the closer planet is always the greater one.

Kepler's work ushered in a time of rapid progress in understanding the solar system. Sir Isaac Newton invented the idea of gravity and used it to explain all orbits. Newton had used the ideas of Kepler and some other astronomers, Galileo, Huygens and Horrocks, to produce a formula for the attractive force that every pair of bodies will have on each other. Newton refused to make any suggestion on how this operation-at-a-distance was achieved.

The questions that worried him were: "How can the two inanimate bodies know that the other exists? How do they know to pull and how hard to pull on each other without knowing their distance apart or their two masses?"
George Darwin was just one of a number of later scientists who wondered what would

happen in special cases of natural satellites orbiting the planets. They thought up special cases involving a total of three bodies (instead of Newton's two) and there was great interest in solving these so-called three-body problems with their total of six gravitational attractions, two for each pairing. Darwin's particular interest was to investigate what would happen as a moon in a smaller orbit caught up to another moon in a slightly larger orbit about the same planet. Astronomers already knew what happened for planets orbiting the Sun where the orbit sizes are quite different. Mercury regularly overtakes Venus, Venus regularly overtakes the Earth and Earth regularly overtakes Mars etc. Would each of Darwin's moons affect the orbit of the other or would the inner one just overtake the outer one as for the planets?

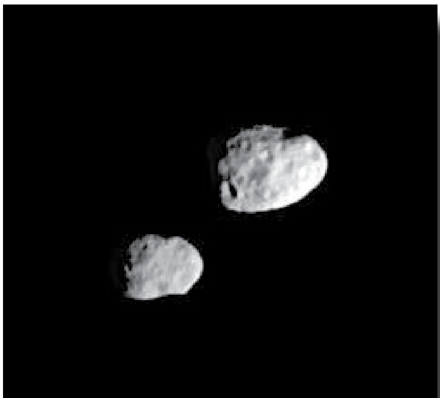
Darwin concluded that if the orbital radii were nearly equal, then, as a collision or an overtaking event seemed imminent, the mutual gravitational pulls would make the inner body move outwards and the outer one move inwards. He realised that these changes would affect the velocities of the two bodies in opposite ways. The trailing body, moving out, would slow down a little and the leading one, moving in, would speed up a little. This change of velocity of both moons would make a collision impossible. It would seem to distant observers that the two bodies had decided to swap relative orbital positions just so that no overtaking wouldoccur. Of course, Darwin had to show that the outward and inward movements would be cancelled.

He realised that during the inward and outward movements, there had to be an instant when the two moons would be at the same distance from the planet. Soon after that instant, the trailing moon that was moving outwards would be subjected to a force pulling it inwards and vice versa for the leading moon that had been moving inwards. In this way the two moons settle back into ordinary orbits. Darwin proposed that after many additional ordinary orbits, the leading moon would become a trailing moon and the possible collision or overtaking event could fail again and this regular orbital dance could perhaps continue for centuries.

Epimetheus
Image Credit: NASA/JPL/Space Science Institute

Darwin's prediction was realised during the Space Age when it was found from the Voyager missions that Saturn had two moons in very nearly equal orbits in planes that are quite close. Janus and Epimetheus have orbital radii of about 151 000 km but differing by only about 50 km. The sizes of the moons were great enough that there would not be room for one to overtake the other. Instead, these moons do a space dance at intervals of about 3 years 10 months and 10 days. In this time, the outer moon covers about 2013 orbits and the inner one about 2014. The numbers are unlikely to be exact whole numbers but they must differ by one.

Collisions are on the way; there is no doubt.
When and how destructive they will be is not known but any attempt to save the Earth from the big ones will certainly be extremely expensive.



Janus and Epimetheus: although the moons appear to be close in the image, they are not. Janus (181 kilometers across at right) is about 40,000 kilometers farther away from Cassini than Epimetheus (116 kilometers across at left) in this view. In fact, even when they are at their closest, tugging at each other and swapping orbital positions, they are never closer than about 15,000 kilometers.
The image was taken in visible light with the Cassini spacecraft narrow-angle camera on March 20, 2006 at a distance of approximately 452,000 kilometers from Epimetheus and 492,000 kilometers.
Image Credit: NASA/JPL/Space Science Institute

Some points to ponder:

1. An interesting notion is that the Earth and its Moon are doing just what Janus and Epimetheus are doing but that they are swapping the inner and outer positions much more frequently.
2. It is interesting to ask the question, "For an observer on Janus or Epimetheus, what appearance does the orbit of the other have?" Is the shape like the outline of a very narrow horseshoe? Will this horseshoe be traversed in seven years eight months and twenty days – i.e., twice the time between two successive failed overtaking events?"

Bob Roeth
This article incorporates the notes made for an IYA presentation to a Seniors Group but has been augmented for use in Reflections.

Erratum: Part 1 of this article, the last word of 1st paragarph should read "quantitatively" and not "qualitatively".

Star Party at Mount White

Finally some good observing! 20 members and guests had a great night on March 20 at Jos Robert's property at Mt. White.

We were greeted by nearly perfect skies and, after a sausage sandwich in the pool pavilion watching the sun set over the Hawkesbury and the Blue Mountains, Jos set up his 24" dobsonian.

About 6 other scopes were also used to look at some great objects, including Tuc47, the Tarantula, Eta Carinae, some planetary nebulae as well as numerous galaxies pointed out by our resident expert, Geoff Unsworth.

It was a balmy night, and at one stage a number of us were on our backs trying to pick out the Emu in the Milky Way, which stretched from one horizon to the other.

Bob Fuller

Reflections is published quarterly by the Northern Sydney Astronomical Society Inc
PO Box 56 Lane Cove 1595 Tel: 0423 971 374 E-mail: nsas@nsas.org.au Web site: www.nsas.org.au