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Mike Frost has been visiting New Zealand and has been to The Carter Observatory in Wellington and Mercury Bay Museum where Captain Cook made observations of a transit of Mercury in 1769

Top: The Mercury Bay Museum Mural. Above: Two views of the Cooke Refractor, a 9¾ inch refracting telescope by Thomas Cooke of York, at The Carter Observatory, Wellington, New Zealand

CONTENTS

How to measure the Density of a Planet from your Back Garden

By Mark Edwards

To find the density of an object it is normally necessary to weigh the object to determine its mass and to measure its size in three dimensions to determine its volume, then we can divide the mass by the volume to find its density. Mathematically we can say:-

$\rho = M / V$ where ρ = density
M = mass
V = volume

How then from our back garden can we measure the size of a planet and weigh it? The answer is that we can't, but we know something that can!

That something is called a natural satellite or moon orbiting the planet. Such a satellite feels the gravitational force of its parent planet and that force depends upon the mass of the planet, the more massive the planet the greater the force. That force is given by Newton's law as:-

$F = G\,Mm / r^2$ where F = force
G = gravitational constant = $6.6743 \times 10^{-11}\ m^3kg^{-1}s^{-2}$
M = mass of planet
m = mass of satellite
r = distance between satellite and planet

So how does this help in determing the planet's mass through introducing two more unmeasurable quantities, the satellite's mass and the radius of its orbit? Again it doesn't, but the satellite has another trick up its sleeve, it is in orbit so its tendency to fall towards the planet is balanced by its motion trying to escape into space. The force it needs to pull against this motion is greater if it is more massive and travelling more rapidly and is given by:-

$F = mv^2 / r$ where v = velocity of satellite
r = radius of satellite's orbit

So we can say that in a stable orbit the two forces, F, are the same, hence:-

$$F = G\,Mm / r^2 = mv^2 / r$$

This simplifies to give:-

$$v^2 = GM / r$$

Here we have eliminated one of our unknowns, m, the mass of the satellite and it reveals an interesting fact that the velocity of the satellite is independent of its mass, it only depends on the radius of its orbit and the mass of its parent planet. This is why an astronaut doing a spacewalk on the space station doesn't shoot off into space or fall rapidly down to Earth, the two are going at precisely the same speed even though their masses are vastly different.

All very interesting, but we still have more unknowns to remove. Starting with v, the satellite's velocity in its orbit. We can go some way to doing this by assuming that it is in a circular orbit, in which case its velocity is simply given by the length of the orbit divided by the time to complete one orbit, so:-

$v = 2\pi r / t$ where t = satellite's orbital period

substituting for v in our previous equation gives:-

$$4\pi^2r^2 / t^2 = GM / r$$

or:-

$$M = 4\pi^2r^3 / (Gt^2)$$

Now we have replaced the unknown velocity of the satellite, by t its orbital period which is something we can easily measure by observation. This still leaves us with having to measure r, the radius of the satellite's orbit to determine M, the planet's mass.

However, remember that we were supposed to be finding the density of the planet, so we also need to measure its volume. Now if we assume the planet is spherical in shape its volume will be:-

$V = 4\pi R^3 / 3$ where V = volume of planet
R = radius of planet

So as its density is given by:-

$$\rho = M / V \text{ or } M = \rho V$$

we can say:-

$$M = \rho 4\pi R^3 / 3$$

We can then replace our unknown planetary mass M by this equation giving:-

$$\rho 4\pi R^3 / 3 = M = 4\pi^2r^3 / (Gt^2)$$

This equation simplifies to give:-

$$\rho = ((r / R)^3 / t^2) \times (3\pi / G)$$

If we now examine this equation closely we can see that we have replaced the unknown lengths r and R by their ratio r / R. This means that we do not need to measure their absolute values, instead we can obtain their ratio either by direct angular measurement or by using a photograph. Measuring the planet's radius, R, is easy by this method, but to obtain r, the radius of the satellite's orbit requires the measurement to be taken when the satellite appears in its orbit at the maximum separation from the planet. Observing it over several days allows both this and the satellite's orbital period, t, to be determined.

If we measure t in days rather than seconds the constant part of the equation becomes:-

$(1 / (24 \times 60 \times 60)^2) \times (3 \pi / G)$ which evaluates to 18.916 kg $m^{-3}s^2$ so our final equation is:-

$\rho = 18.916 \times (r / R)^3 / t^2$ kg m^{-3}

Now we are armed with a simple method of finding a planet's density, we have the problem that two planets (Mercury and Venus) don't have natural satellites. Mars has two, Phobos and Deimos, but they are very small and faint (magnitudes +11 and +12 at Mars opposition) and are also very close to the planet.

Jupiter is a much better prospect as its four largest satellites are easily visible at magnitudes +4.6 to +5.6 and lie at reasonable distances from the planet. Having four sets of measurements also helps to increase the accuracy of the result.

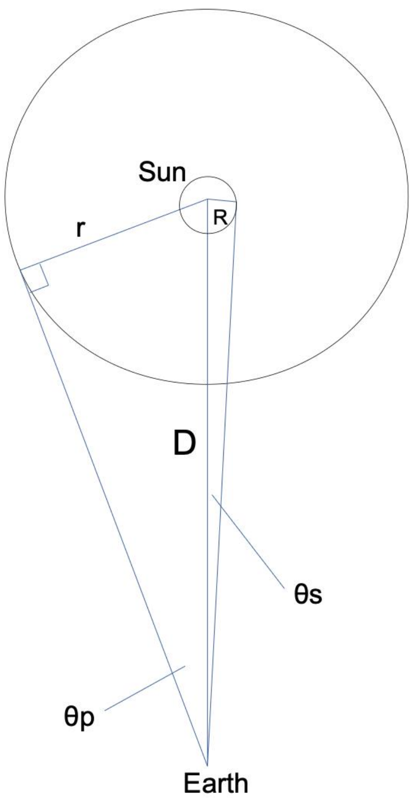
Similarly Saturn's largest satellite, Titan, at magnitude +8.4 would be equally as good for finding the density of Saturn as a comparison.

Finally, as a check of the equation's validity, does it work for the Earth which has a handy large satellite that we can easily see? The Earth isn't quite spherical, but its average radius is 6371 km. The Moon's orbit is also not quite circular, but the semi-major axis of its elliptical orbit is 384,748 km and its sidereal orbital period is 27.322 days. Plugging these values into the formula gives:-

$\rho = 18.916 \times (384748 / 6371)^3 / 27.3222 = 5581$ kg m^{-3}

The accepted value is 5513 kg m^{-3} so that is a pretty good approximation!

So I look forward to seeing your planet density measurements!



Measuring the density of the Sun

After explaining how the density of a planet could be derived from observations of the orbits of its satellites it occurred to me that the same method could be used to derive the density of the Sun. Remember that the formula for a planet's density is $\rho = 18.916 \times (r / R)^3 / t^2$ kg m^{-3} where r is the radius of a satellite's orbit, t its orbital period and R the radius of the planet. For the Sun's density we use the orbit of a planet instead.

So r becomes the radius of the planet's orbit, t its orbital period and R the radius of the Sun.

How can we obtain these from simple observations? The diagram shows the measurements we can make. These are the angular radius of the Sun, θs and the maximum elongation of the planet, θp. Now the line of sight from the Earth to the planet at maximum elongation forms a tangent to its orbit, so sin(θp) = r/D, where D = distance from the Earth to the Sun. Similarly for the Sun it is a tangent to the Sun's surface so sin(θs) = R/D.

Dividing these two gives sin(θp) / sin(θs) = r/R which is the radius ratio we need for the formula.

So the Sun's density = $18.916 \times (\sin(\theta p) / \sin(\theta s))^3 / t^2$ kg m^{-3}

This equation only works for the two planets that orbit closer to the Sun than Earth, i.e. Mercury and Venus. Of these Venus's orbit has a very low eccentricity of 0.007, so the assumption that the orbit is circular holds. Now using values for the planet Venus when it is next at its greatest elongation east on 14th August 2026:-

θp = 45.9°, t = 224.7 days and θs = 0.263° giving a density of 1,434 kg m^{-3}

Which is a good approximation to the accepted value of 1408 kg m^{-3}

An Attempt to Measure the Distance to Quasar 3C 273

By Tony Green

I **have to admit that I'm not great at DIY.** Using a tape measure and spirit level to figure out where I should drill holes for a new set of shelves typically takes 4-5 times longer than it should. Even then, I often get it wrong and I resign myself to the merciless teasing by my partner that quickly follows.

So when I decided to have a stab at measuring the distance to a far-off quasar, I took some comfort knowing that if my measurements were off by a 100 million light years or so (which dear reader, is somewhat larger than measurement errors commonly found in my DIY projects), any raised eyebrows from my partner would be met with my go-to defence in these matters: better results require bigger and better equipment.

3C 273 is a quasi-stellar object that lies in the centre of a large but faint elliptical galaxy in the constellation of Virgo. 3C 273 is interesting for many reasons – not least the size of the supermassive black hole at the centre of the galaxy. When we observe 3C 273, the light we see is from the colossal amount of energy released as material is ripped apart as it spirals into the black hole. The light is so intense, it outshines the galaxy itself!

Furthermore, when the first spectra of quasars were taken, it was a while before astronomers realised that the peaks they were seeing were from the Balmer series of hydrogen lines that had been subjected to large displacement ("red-shifted") due to the Doppler Effect. Once astronomers had made the link, it was relatively straight forward to identify the key lines in the spectra of these distant objects with those from a source at rest ***[1, 2]***.

The Alpy 600 from Shelyak Instruments ***[3]*** is a low-resolution spectroscope that can resolve spectral lines 10Å (1nm) apart. At magnitude 12.9 (variable) would 3C 273 be bright enough to allow the red-shift to be determined with reasonable accuracy using an Alpy 600 spectroscope? The following describes my attempts to find out.

Acquiring the Spectrum

For any spectroscopic work, the instrument must first be carefully calibrated. I do this by taking the spectrum of a Neon/Argon calibration lamp (supplied by Shelyak) and matching the peaks with known emission wavelengths using the Demetra software package. The calibration spectrum is shown in *Figure 1*. Note that in this case, sharp peaks are observed at 5852Å * but at longer wavelengths, a slight distortion observed in the shape of the peak. I've found this to be a common issue with my Alpy 600 setups and therefore for quantitative analysis, I avoid making use of signals found at longer wavelengths.

The next step is to identify 3C 273 in a star field. The AAVSO (for example) provides a star finder map that is helpful to identify the correct target in the star field ***[4]***.

After identifying the target, the scope needs to be carefully positioned so that the star appears centred on the slit. This process isn't particularly easy and has tested my patience on several occasions!

Figure 2 shows the image taken by the off-axis guide camera with 3C 273 positioned on the 23µm slit. The fact that there is very little signal to see in this image is a good thing as all the light is passing through the slit onto the spectroscope and not being reflected onto the OAG camera!

Once positioned, several spectra are taken with10 minute exposures. The Demetra software package is used to reduce and stack the images using bias, dark and flat masters. This process is essential to remove camera artefacts and the relatively strong signal from light pollution *Figure 3*.

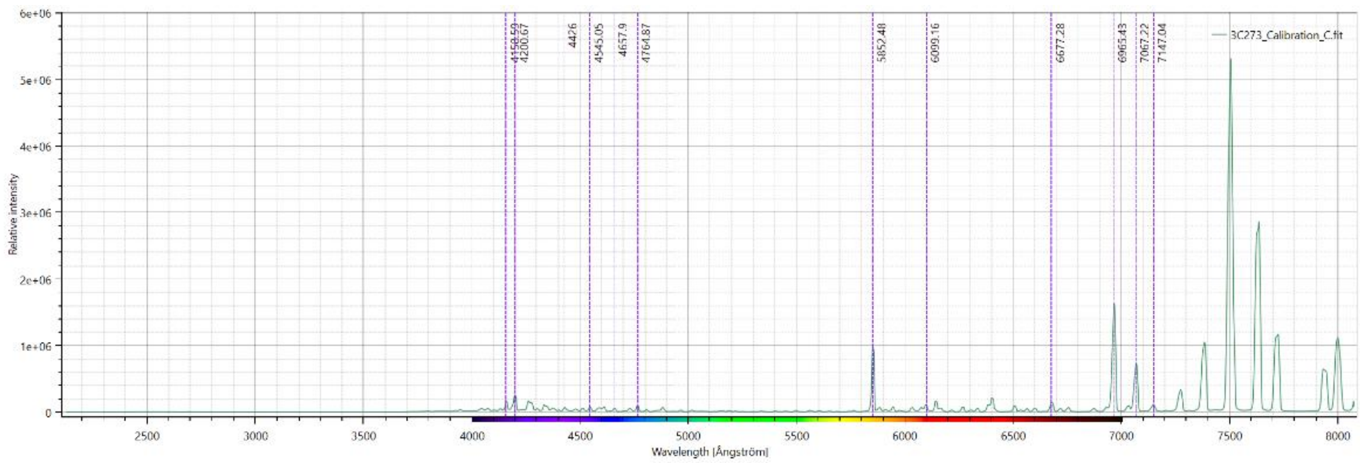


Figure 1. Neon/Argon calibration spectrum with peak assignments

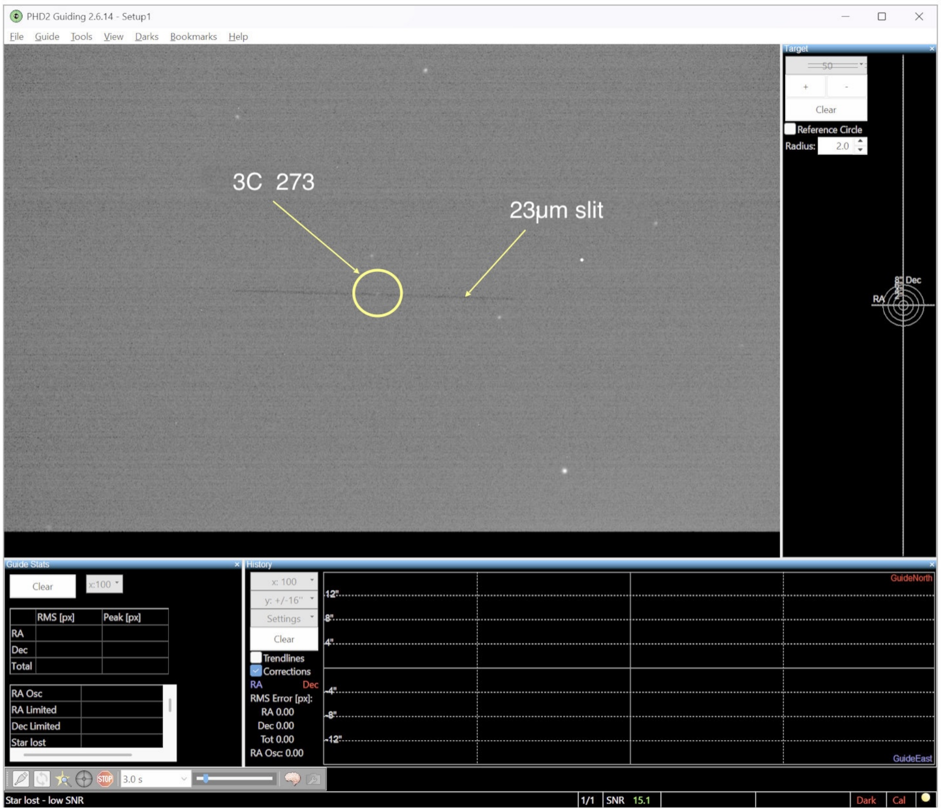


Figure 2. Off-axis guide image showing the target positioned in the middle of the slit shown by the faint line

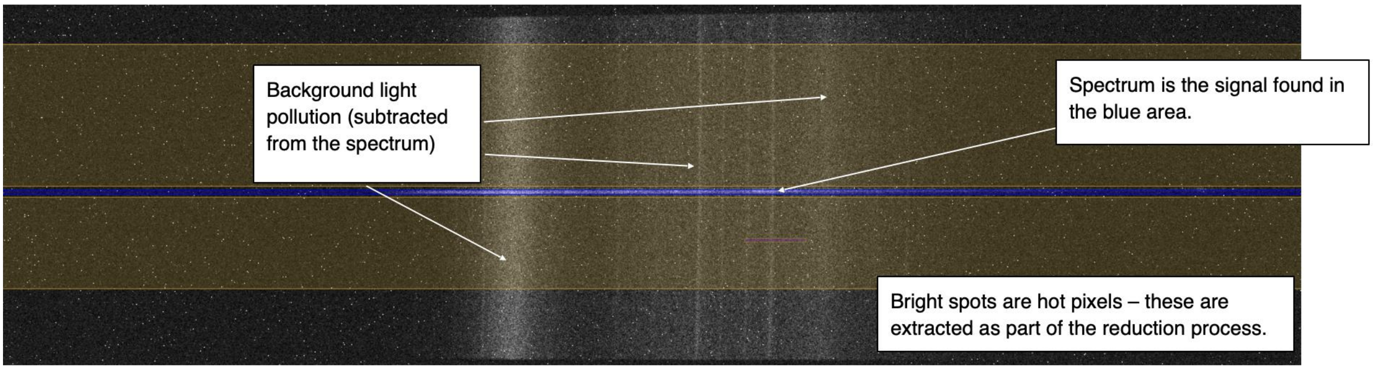


Figure 3. 600 second exposure showing the signal in the thin blue area. The other areas are used as part of the calibration process

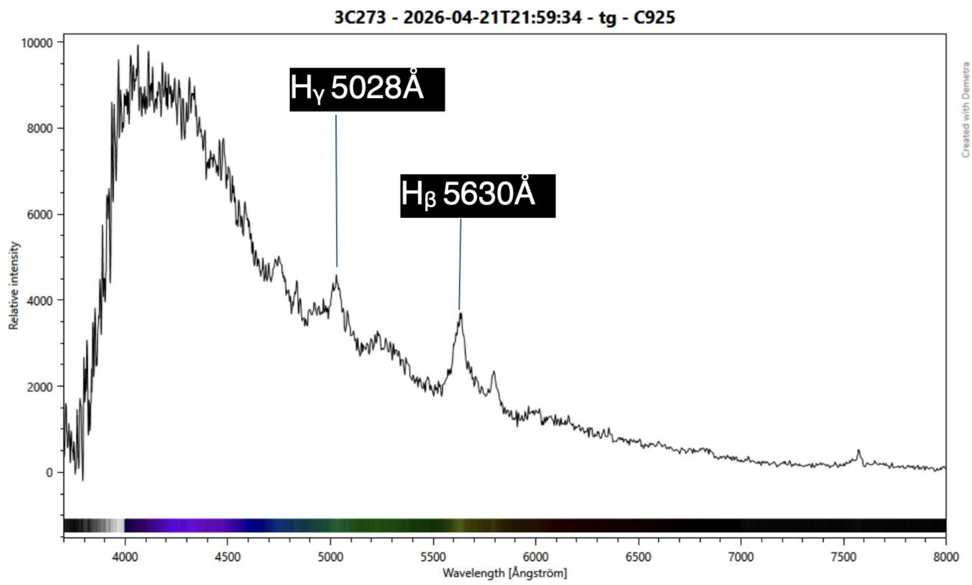


Figure 4. Spectra of 3C 273 (8x600 sec exposures)

Emission Line	At Rest Wavelength/ Å (λ_0)	Measured Wavelength/ Å (λ)	Red-Shift $z = (\lambda - \lambda_0)/\lambda_0$
H_β	4862	5630	0.1579
Hγ	4340	5028	0.1585
OIII	5007 / 4959	5795	0.157

Table 1. Measurement of red shift

The resulting spectra *Figure 4* compares well with other published spectra ***[5]*** apart from the Hα signal that was lower in intensity than expected. The peak at around 5800Å is the red-shifted OIII (doubly ionised Oxygen) signal with the at rest wavelength of 5007 Å with contribution from a weaker component at 4959 Å.

Cross checking my results with published spectra was critical here as there would be no way for me to assert that the peaks at 5028Å and 5630Å were due to H_γ and H_β!

Determining the Red Shift

The equation to determine red shift (or "z") is relatively simple:

$z = (\lambda - \lambda_0)/\lambda_0$

where:

λ_0 is the "at rest" wavelength and λ is the measured wavelength.

The "at rest" wavelengths for H_γ and H_β are 4340 Å and 4862Å respectively. Using the measured values of 5028 and 5630Å, the z becomes 0.1585 and 0.1579 which turns out to be in agreement with the literature value of 0.158!

Determining the distance

Determination of the distance to 3C 273 can be made using a simple approximation:

$$d \approx \frac{c.z}{H_0}$$

where:

c = the speed of light
z = red shift
H_0 (the Hubble Constant) = 70 km/s/Mpc

This leads to a distance of
d ≈ 299,792 * 0.158 / 70 mega parsecs
d ≈ 676.67 megaparsecs or **2.20 billion light-years**.

More accurate tools exist online to convert red-shift to distance but at this point, we start to get into the complexities of understanding the differences between co-moving distance, how long ago we see the object, how far light actually travelled – all of these are different. For example, the SpaceTimeMesh red-shift calculator ***[6]*** provides the following information for an object with a red-shift of 0.158:

Current distance in the expanding universe:
2.20 billion light years
How long ago we see this object:
2.05 billion years
Distance light has actually travelled:
1.90 billion light years
Speed that the object moves away from us:
14.6% speed of light

Concluding Remarks

With 80 minutes integration time, the identification of the key Balmer hydrogen emission lines are easily detectable using an Alpy 600 and Celestron Edge 9.25. It is possible that measurements could be made using smaller aperture equipment and cheaper, lower resolution spectroscopes.

Compared with the spectra of stars that often exhibit relatively sharp peaks, the emission peaks exhibited in 3C 273 are very broad. This is an indication of the colossal speed of the matter falling into the black hole, but more detailed explanations can be found in the literature ***[7]***.

It seems utterly insane to me to think that using modest amateur-level equipment we can make estimates of the distance to objects at the outer reaches of the universe that tally with professional observations! However, after showing these results to my partner, I'm not entirely sure her confidence in my DIY skills has changed all that much. Maybe if I go for another target and get similar results?

References

[1] The Quasar 3C 273, `www.aavso.org/vsots_3c273`
[2] 3C 273 – A Star Like Object with Large Red Shift, *Dr M. Schmidt, Nature, Volume 197, Issue 4872, pp. 1040 (1963).*
[3] Shelyak Instruments, `www.shelyak.com`
[4] AAVSO Star Finder Chart for 3C 273, `apps.aavso.org/vsp/chart/X42186AF.png`
[5] Quasar 3C273 Optical Spectrum and Determination of the Redshift, *Richard Walker, (2019)*
[6] Redshift Calculator, `spacetimemesh.com/redshift-calculator/`
[*7*] Structure of the broad-line region of 3C 273, *M. Dietrich, S.J. Wagner, T.J.-L. Courvoisier, H. Bock, and P. North, Astronomy and Astrophysics, 351, 31–42 (1999)*

* The Ångström is the commonly used scale in spectroscopy. 1 Ångström (Å) = 0.1nm

The Carter Observatory, Wellington, New Zealand

By Mike Frost

I recently retired from my forty-year career in engineering. This was entirely with one organisation, although it changed names seven times, starting as GEC and ending as GE. Most of the time I specialised in systems and control engineering for the steel rolling industry and I visited steel mills all around the world. Almost the first of these was at Port Kembla in New South Wales, Australia. I spent ten months in New South Wales, and then, having accrued a lot of holidays, I took the long route home and spent a couple of weeks touring the South Island of New Zealand.

I loved Australia but I was blown away by the South Island – Milford Sound and Fjordland, Queenstown, Christchurch (pre-earthquake) and Mount Cook. Ever since I left New Zealand in 1988, I have been wanting to return – in particular, to visit the North Island. But, as it's such a long way to go, a visit there shouldn't be short, so I made it one of my retirement plans. Additionally, an old friend of mine from university had emigrated to New Zealand, and every time I saw him in the UK, he invited me to come and visit him. So, I had a base for the first part of my New Zealand retirement holiday – Wellington, the capital of New Zealand.

So, on Friday February 5th this year, I arrived in Wellington. The city isn't large, home to two hundred and ten thousand people, but as a national capital it punches above its weight culturally. I visited the National Museum; saw the Sistine Chapel (there was a Michelangelo exhibition); toured the Zealandia wildlife habitat, with its Jurassic Park-like fences to keep out foxes and cats. I took the cable car up one of the city's many steep hills to visit the excellent botanical gardens. But, of course, I wanted to make a visit to a site inside the gardens - the Carter Observatory.

The Carter Observatory, an observatory for the people of Wellington, is at the top of a ridge overlooking the city centre. It shares a small campus with the Dominion observatory, which used to host New Zealand's timekeeping services, but is now occupied by a private company. There is also a meteorological observatory; and the Thomas King dome, which houses a 5-inch Grubb telescope dating from 1886. These days the observatory is known as *"Space Place at the Carter Observatory"* (Te Ara Whanui ki te Rangi) and is run as a museum, one of a collection of venues run by Experience Wellington, a charitable foundation set up to manage the city's cultural heritage. The original redbrick buildings of the observatory, built by William Gray Young, have been extended, and there is a "solar system garden" in front of the main entrance.

The observatory was founded in 1937 from the estate of Charles Rooking Carter, an immigrant from England. There had already been a city observatory, "The Tin Shed" on the site, dating from 1924. Carter wanted the Royal New Zealand Astronomical Society to have a research centre in the capital, and this finally opened in 1941, as the country's National Observatory.

The centrepiece of the historic observatory is a 9¾-inch refracting telescope by Thomas Cooke of York. It dates from 1867, and was originally bought by Edward Crossley of Halifax, Yorkshire. Crossley and his observer Joseph Gledhill used the telescope for many decades of observations from the Bermerside Observatory in Halifax (there was also a much larger 36-inch reflector purchased from Andrew Ainslie Common, which ended up at the Lick Observatory). In 1905, after Crossley's death, the Cooke telescope was sold to Reverend Dr David Kennedy and installed in a seminary near Napier, on the east coast of NZ North Island; it was used to photograph Halley's Comet in 1910. The telescope was sold to Wellington Council in 1923. For many years it was a research telescope, used for solar observation and observation of flare stars and double stars.

The Cooke refractor is in excellent repair and is still used for public stargazing – but of course I was in Wellington during summer, so there were no stargazing sessions at that time of year. The objective lens was replaced in 2001, but the gravity drive installed by Grubb is still in place and still used to drive the telescope.

Close to the Cooke dome is another historical gem, the Carter Observatory library. This also dates from the second world war and was founded by New Zealand-born astronomer Leslie Comrie (1893-1950). Comrie, who lost a leg in the first world war, was employed at the Greenwich Observatory in London, where he pioneered the use of mechanical computers for astronomical calculations; indeed, he was the first director of the BAA's computing section in 1919. His use of calculators created tension in the observatory and he was eventually dismissed, going on to found computing companies and carrying out computational work for the war effort. He revisited New Zealand in 1948 (en route, he saw the green flash and wrote a letter about it to the BAA Journal). He was concerned that war would break out again in Europe, potentially destroying civilization in the Northern Hemisphere, and resolved to create an astronomical library in New Zealand to preserve knowledge.

The Cooke telescope and the Comrie library form part of the exhibition area of the Space Place. There are plenty of other exhibits, similar to what you would find in any other science centre around the world (there is nothing wrong with this!). Having visited many such science centres, I was interested in the exhibits which were unique to New Zealand, focussing on the Pacific and Maori heritage. I was intrigued by the star lore and particularly interested in the exhibits on Pacific navigation by the stars.

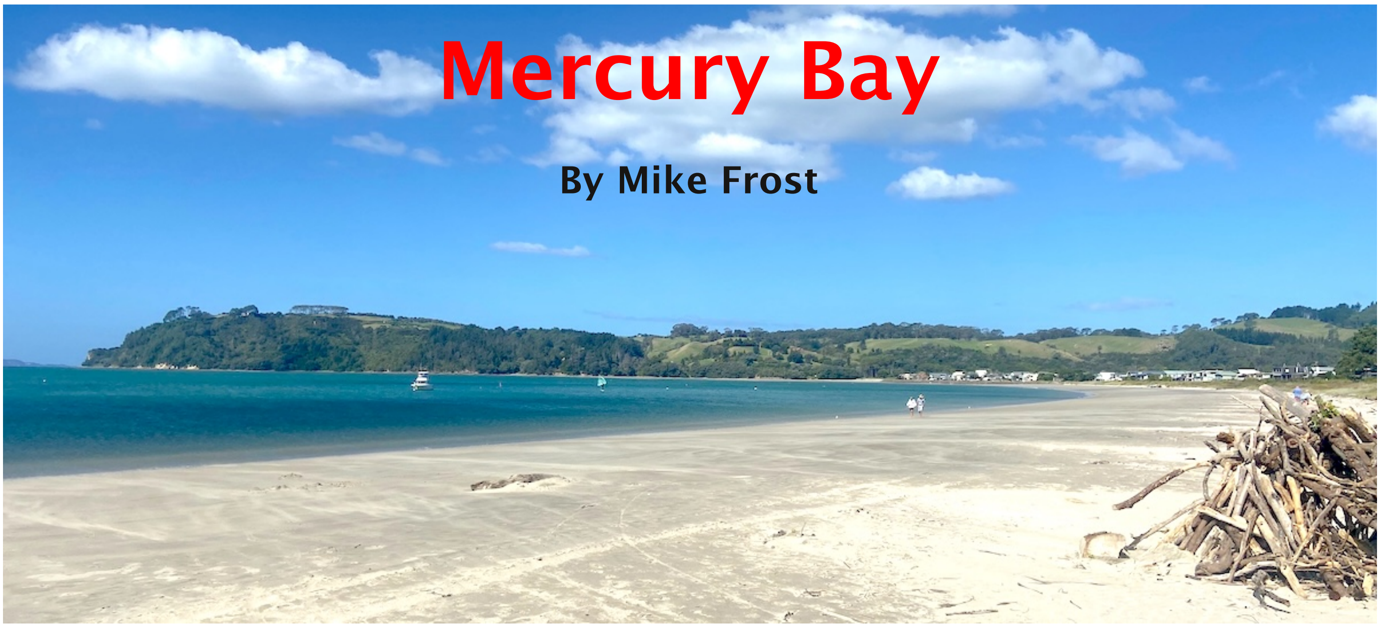
The centrepiece of the Space Place is the planetarium. In 1991, this was relocated to the Carter Observatory from downtown Wellington. I opted to view *"The Navigators"* (Nga Tohunga Whakatere), an immersive show which takes us with Moki, a young Pacifika girl, as she travels with the Polynesian sailors who first reached New Zealand in the 1200s, and then with Abel Tasman, the first European to reach New Zealand (the South Island, in 1642) and Captain James Cook, who circumnavigated both islands in 1769 after viewing the Transit of Venus from Tahiti. It's a great show. I was even more impressed that our host in the planetarium followed up with a short but informative tour of the night sky from Wellington that evening, tying in what could be seen to European and Maori star-naming traditions.

The Carter Observatory is no longer a research establishment – the change of name to *"The Space Place"* reflects its changing role into a museum and science centre. But it is still at the heart of Wellington, still much loved by the people of the city. I enjoyed my visit.

Sources:

`https://en.wikipedia.org/wiki/Space_Place_at_Carter_Observatory`
`https://www.museumswellington.org.nz/about/our-story/`
`https://en.wikipedia.org/wiki/Leslie_Comrie`
"The Green (?) Flash (?)" Comrie, L.J. (J. Br. Astron. Assoc, 58:7 p 280)
In the letter Comrie suggests the phenomenon is partly physiological, and partly the result of an uneven sea horizon due to sea swell. Neither is now the accepted explanation.
`https://en.wikipedia.org/wiki/Edward_Crossley`

The Dominion Observatory (no longer used as an observatory)



Mercury Bay

By Mike Frost

Cooks Beach, in the direction of where the Transit of Mercury was observed

One of the many highlights of my recent holiday to New Zealand was visiting the Coromandel peninsula, to the east of Auckland on the New Zealand North Island. I stayed for a couple of days at the resort of Whitianga and took a boat trip to the marine reserve of Cathedral Cove (which you might recognise from the Narnia movies), where I enjoyed the snorkelling.

Eliza, our guide for the trip, was keen to tell us how Mercury Bay got its name. She produced a flash chart showing us a Transit of Mercury. For Mercury Bay was the location where Captain James Cook, astronomer Joseph Green and Lieutenant Zachary Hicks observed a transit of Mercury on November 9th 1769. I already knew this from one of the posters which Wayne Orchiston sent me for display at BAA historical section meetings. Once we had docked back at Whitianga, I took the ferry across Whitianga estuary, to visit the spot where the transit took place.

What was Cook doing in New Zealand, and why was he observing a transit of Mercury? Let's go back to examine one of the great voyages of exploration.

In 1768, Captain James Cook was commissioned by the Royal Navy to sail to Tahiti, to observe another transit – this time of the planet Venus. This was part of an international series of expeditions to send astronomers to locations scattered across the world. By careful measurement of the path of Venus across the Sun – in particular, careful timing of contact events at known locations – distances on Earth could be related to distances on the Sun, giving a parallax measurement for the Sun and so finally determining the size of the solar system. The relative size of planetary orbits had been known since the work of Johannes Kepler in the early seventeenth century, but the size of the Astronomical Unit, the distance from Sun to Earth, was still only estimated.

Cook set off in the barque Endeavour, rounding Cape Horn and sailing westwards across the Pacific Ocean. He arrived at Tahiti on 13th April 1769, spent several weeks verifying its latitude and longitude, and successfully observed the transit of Venus on June 3rd 1769.

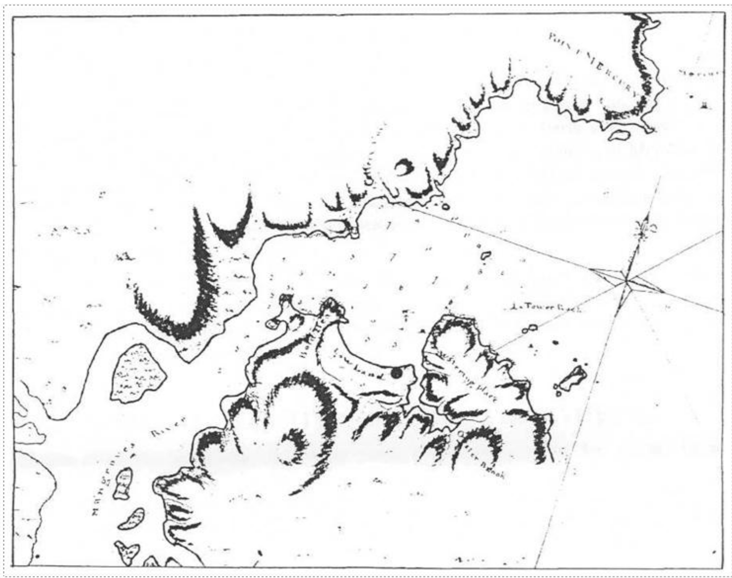
Cook's next orders, kept secret when the voyage was announced to the public, were to sail south from Tahiti and find unknown lands in the southern Oceans. The Dutch navigator Abel Tasman, over a century previously, had discovered the island we now know as Tasmania, and the South Island of New Zealand, which he thought might be part of an otherwise unknown southern continent. Tasman had not landed on New Zealand as he encountered a hostile reception from the native Maori, but he eventually gave the name New Zealand to the land he found.

Captain Cook encountered New Zealand for the first time on October 9th 1769, landing close to present-day Gisborne on the east side of the North Island. After some preliminary journeys, Cook began a systematic circumnavigation of New Zealand, finding in the process that there were two separate islands separated by the strait now named

Table 1: Observations of the November 1769 transit of Mercury, Mercury Bay, Coromandel Peninsula

Event	Observer	Local Time
Internal Contact	Cook	12h08m45s
	Green	12h08m58s
External Contact	Cook	12h09m43s
	Green	12h09m55s

Figure 1: Cook's **map of** Mercury **Bay. The "Observatory"** site is **marked** by **the black dot.**



for him. The third anchorage of the circumnavigation, on November 4th, was at Whitianga, and it was from here that he decided to observe the Transit of Mercury.

The Tahiti transit of Venus is one of the great astronomical observations. So why isn't the later transit of Mercury better known? Because it was NOT made for astronomical purposes. There are two reasons for this. First, the parallax of Mercury against the Sun is less than a fifth of the parallax of Venus, because Mercury is much closer to the Sun; measuring the parallax of Venus was already close to the observational limits of Cook's equipment. Second, the much smaller angular size of Mercury means it is more difficult to measure (Cook and Green took timings of the third and fourth contacts, differing by 12 and 13 seconds respectively). Instead, it is generally thought that the Mercury Bay transit measurements were used to find the longitude of Whitianga.

I confess to being a little baffled by these explanations. A huge amount of effort was put into sending expeditions around the world to record the June 1769 transit of Venus. Was it not worth these expeditions also making measurements (perhaps at locations on their way home) of the November transit of Mercury? An interesting paper in 2010 by Bill Keir suggests that Cook's Mercury transit observations weren't particularly useful for longitude determinations either.

The beach from which Cook, Green and Hicks observed is called Cooks Beach (no apostrophe) and it is two miles walk from the ferry landing. The area behind the beach has been developed as a seaside community, and many of the roads have names commemorating the event – Captain Cook Road, Charles Green Drive, Hicks Place and Endeavour Place. Wayne Orchiston has identified the location on the beach (toward the eastern end) where the observations were made from, but, as far as I can see, there is no monument there – other than the road to the beach being called Transit Street.

Instead, there is a monument half a mile away, on Shakespeare Cliff, which forms the western end of the beach. Wikipedia informs me that the first monument to be erected there was washed away by a storm and erosion in 2018, but a replacement monument was built before the 250th anniversary of the transit in 2019. I would have climbed the cliff to see the new monument – but I had a ferry to catch, so I headed back to Whitianga instead.

The next day, before heading off to the next destination on my tour (the splendid Hobbiton film set), I took the opportunity to visit Whitianga Museum. Captain Cook's visit to Mercury Bay is only a small part of the history of the town, of course, but nonetheless there is a very good gallery celebrating the twelve days which Captain Cook and his crew spent in Mercury Bay, telling the story from Cook's and Bank's journals and from the oral history of the local Ngati Hei Maori. There is also an impressive mural on the wall of the museum.

Sources:

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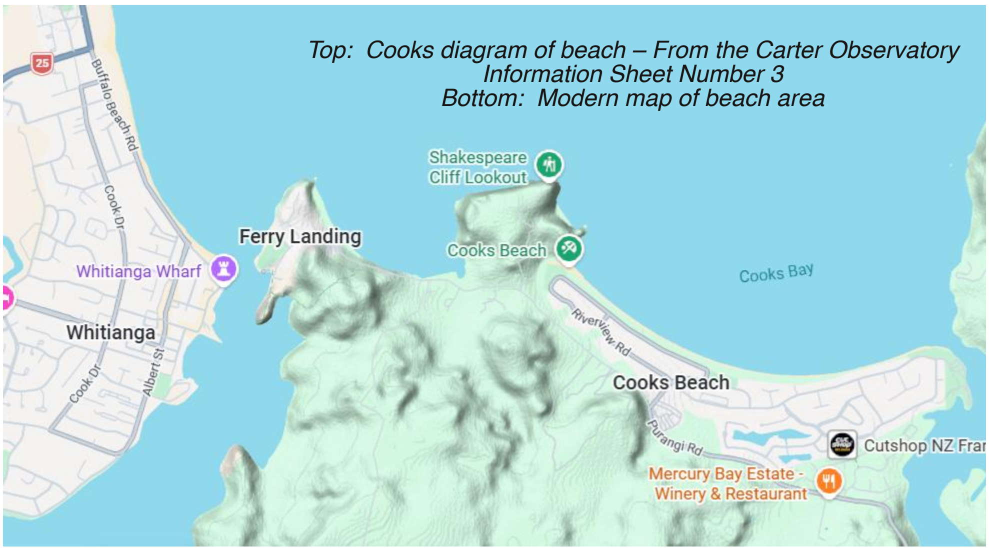
"Captain Cook's longitude determinations and the Transit of Mercury – common assumptions questioned", Bill Keir, Journal of the Royal Society of New Zealand, 40:2, 27-38 (2010)



Top: Cooks diagram of beach – From the Carter Observatory Information Sheet Number 3
Bottom: Modern map of beach area