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Cover - : The daily firing of the noon gun from Signal Hill in Cape Town was opened to the public from February 1997 so they could witness the oldest guns in the word still in daily use. The two guns are fired alternately, with the second being the backup, should the "duty" gun misfire (Photo by the late Geoff Evans, courtesy of W Koorts) See page 31.

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News from SAAO

Acting Director SAAO

Following the resignation of Dr Petri Vaisanen, Dr Angus Peterson, Deputy CEO of NRIP, announced on 2 February that, while the search for a new Managing Director is being concluded, Dr Rosalind Skelton will be the SAAO Acting Managing Director. “Dr Skelton has played a leadership role within SAAO, SALT and NASSP and I am sure she will manage this position with aplomb”.

OAD Deputy Director

Charles Takalana has been appointed as the new OAD (IAU Office of Astronomy for Development) Deputy Director, taking over from Vanessa McBride. For a transition period from 1 May to 31 August he will serve as Interim Head of Secretariat of AfAS and particularly continue his efforts towards the IAU General Assembly as the deputy chair of the National Organising Committee to ensure that the GA proceeds smoothly.

Star Trails Photographic Polar Alignment Method (STPPA)[1]

Oleg Toumilovitch (ASSA)

Introduction

Image 1

The proposed method for Polar alignment of an Equatorial Telescope Mount was initially developed in early 2008 during visits to Waterberg, in preparations for the first Planetary Festival which took place in August 2008-2009-2010.

Using a TAL-100 (100 mm F/10) refractor telescope on TAL motorized equatorial mount and quick polar alignment in the field was essential for continuous live video and images projection on large screens for audience. By 2012 the draft of the “Photographic method of Polar alignment of an Equatorial Telescope Mount” was completed with the intention to present it at ASSA Symposium 2012. Unfortunately, both 2012 and 2014 events were cancelled by the organizers.

Since then number of friends have been introduced to this method and are making use of it when required. I would like to express my gratitude to all my friends and number of rangers at private nature reserves, who have participated in this project over the years in one way or another, with special thanks to Wens Coetzer, Ben Bester, Dieter Willasch, Neil Summers, Andy Overbeek, Frank Barbato.

Equipment required

A digital camera or specialized astronomical camera is needed for this method. The method is universal in full meaning of the word and is applicable for both, Southern and Northern hemispheres, as well as for both equatorial mounts and Alt-Az mounts, mounted on equatorial wedge, but terminology would be different for Alt-Az mounts.

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[1] The name “Star Trails Photographic Polar Alignment Method” (STPPA Method) Is subject to copyright © Oleg Toumilovitch.

As an example, Celestron Advanced VX mount, installed in Southern hemisphere, is used in this document.

Step 1: Setting up the Tripod, Mount and OTA (Optical Tube Assembly)

1.1 Level the Tripod with the aid of available tools (spirit level, digital level or an app on mobile phone). Leveling is required only for ensuring stability of the telescope, but errors in leveling of an equatorial mount do not affect accuracy of tracking or go to function of computerized telescopes.
1.2 Install the Telescope Mount on Tripod. Tighten Mounting Knob (Fig 1 below) so that the mount is secure but can still be turned about it's vertical axis by hand.
1.3 Add the OTA and required additional equipment and balance counter weights properly.
1.4 Using RA Clutch Lever and Declination Clutch Lever (Fig 2 below) align RA and DEC index marks. This is an approximate alignment, as the Index Marks are not precise. Using the Altitude adjustment knobs (Fig 3 below) set the R.A. axis to the correct Altitude for required location.
1.5 Turn the mount about its vertical axis in any direction where bright stars are visible in the field of view and tighten the Mounting Knob (Fig 1 below)

Step 2: Align the optical axis of the OTA with the mount's R.A. axis (Polar Axis)

This is very important step, which will "convert" your ? into a powerful Polar Scope.

2.1 Focus OTA on preferably bright stars in the field of view.
2.2 Camera: ISO 800-3200, exposure 10-20 seconds. It is better to use higher ISO settings because the stars in the field of view will move fast.
2.3 Loosen the RA Clutch Lever (Fig 2 below) and release shutter on camera. While camera is taking 20s exposure, swivel the assembly around the Polar Axis once or twice until the end of exposure. Tighten the RA Clutch Lever (clamp) Check photograph, it might look like this:

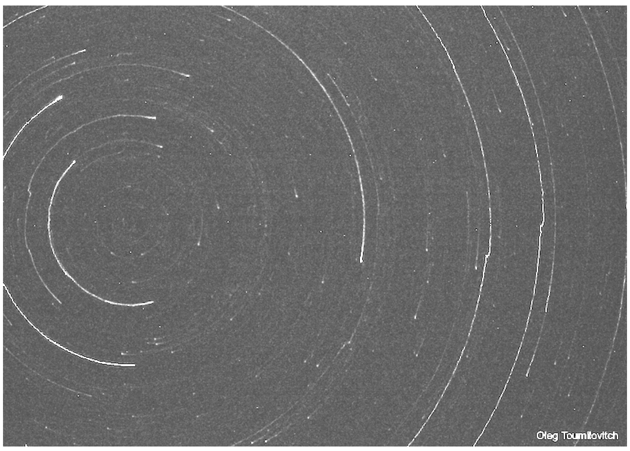


Image 2

2.4 Adjust Declination (using Declination Clutch Lever (clamp) and knobs to bring the pivot point to centre of camera's viewfinder or screen / monitor. Tighten Declination Clutch Lever (Fig 2 below).
2.5 Repeat the Step 2 process until very good alignment is achieved (it can be

checked by zooming into the centre of the image), then tighten clamp securely.
At this point the OTA becomes a powerful "Polar Scope".

Final image, showing precise alignment of OTA optical axis with mechanical polar axis of the mount should look like this:

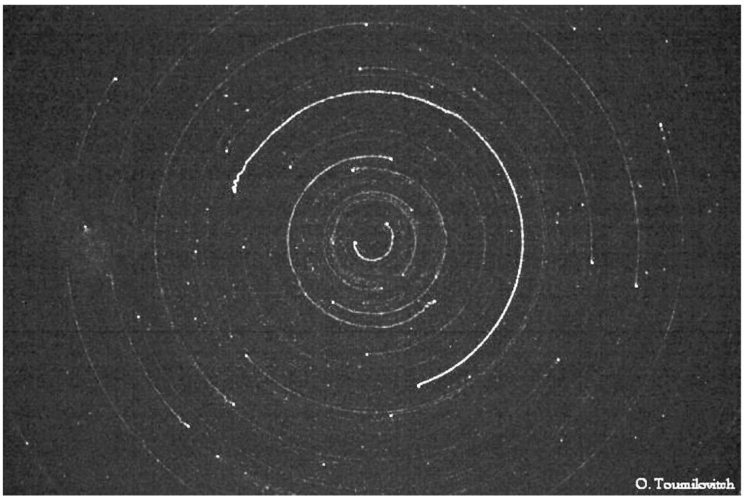


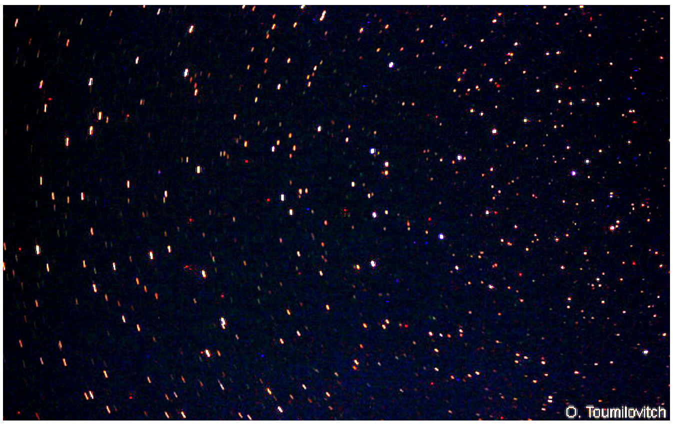
Image 3

Accuracy of alignment can be visually evaluated by zooming into the centre of the image in image preview mode (if DSLR camera is used). If there are very bright stars in the field of view, "live View" function can be used with on-screen Grid display option enabled. This will make it easier and quicker to allocate the centre of the Field of view.

Step 3: Polar Alignment

3.1 Loosen Mounting knob and turn the mount until Polar Axis points roughly to Celestial Pole (SCP or NCP)
3.2 Loosen Mounting Knob (Fig 1 below) slightly.
3.3 Camera: 100 ISO, exposure 30 seconds or more. This should be done over long exposures. The longer exposure – the better circular pattern could be seen. Interesting point is that shorter focal length OTA will require longer exposure. As a reference, with Onyx 80 (500 mm FL) exposures of 2-3 minutes were used. Check the image, it might look similar to this image:

Image 4

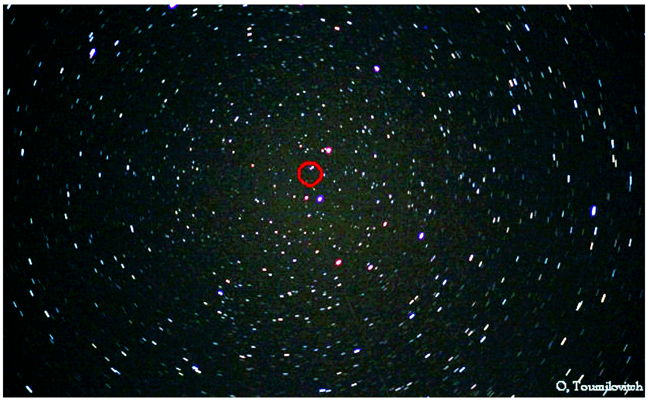


This image clearly shows that SCP is somewhere close to the right edge; the whole mount must be turned toward west (to the right).

4.1 Adjust the Mount using both Azimuth Adjustment Knobs (Fig 3 below) to centre the pivot point (the SCP) in the camera's viewfinder or screen / monitor. Do it in

small steps- loosen one knob by half of a full turn, then tighten another knob by the same amount.
4.2 Repeat until very good Polar Alignment has been achieved. Again, the accuracy of alignment can be confirmed by zooming into the centre of the image in Image Preview mode (when DSLR camera is used).

Image 5



Once you have achieved good polar alignment, one is encouraged to take few sets of images of the SCP region at ISO 800 – 3200 over various exposures for further reference. Very long exposure 5-10 minutes at ISO 100-200 will also produce a very rewarding narrow field image of SCP, showing how fast the Earth is spinning.

5.1 **Until now the mount still wasn't powered-up and everything was done manually**. **Also, there was no need to refer to any specific stars, but after completing these easy steps the observer finds him/herself looking directly into the Celestial Pole.**
5.2 Once comfortable with the technique, corrections of axis position could be done using the mount's hand control unit, if that appears to be more interesting. In this case clamps will not be released.
5.3 When properly Polar Aligned and tighten the Mounting Knob (Fig 1 below)

Conclusion

The Star Trails Photographic Polar Alignment Method is simple and precise, it takes short time to complete and is very good practical exercise for any amateur astronomer with a camera. It can and should also be used to test the polar alignment of permanently installed and polar-aligned telescopes in observatories. During the process, various defects and shortcomings in mechanical and optical assemblies might be "discovered", but this is a subject for another project.

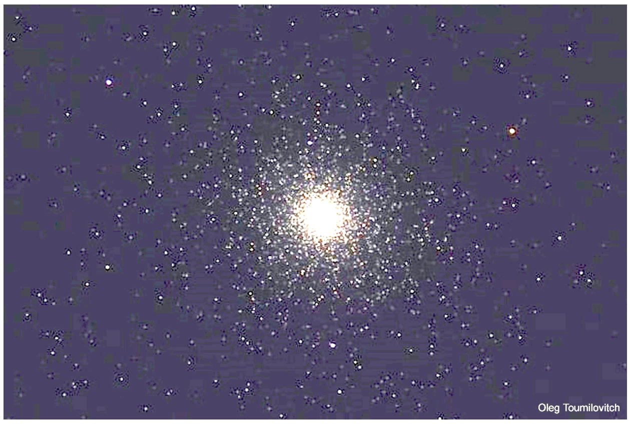
An important factor to take into account is the effect of atmospheric refraction on the apparent position of Celestial Pole for simplicity, but it will be discussed in due course. It would be worth mentioning though, that for South African observers, based between Latitudes 22.2˚ S - 34.8˚ S, the difference between true and apparent altitude position of the SPC is approximately between 1.0 and 2.0 minutes of arc.

Accurate polar alignment is crucial for ensuring that long exposures can be taken without producing unwanted star trails in astronomical images. So it's best to use the

"Star Trails Photographic Polar Alignment Method" to make sure that there are no star trails in one's long exposure images!

Below is an example of long exposure image (327s), which was acquired after STPPA method was done. No auto guiding or manual guiding were used, only mount's tracking.

Image 6
NGC 104 / 47 Tucanae
Image details:
Onyx-80 ED F/6.3
Canon 550D
5.5 min (330s) single exposure @ ISO-100
Takahashi EM-11



Figs 1 & 2:

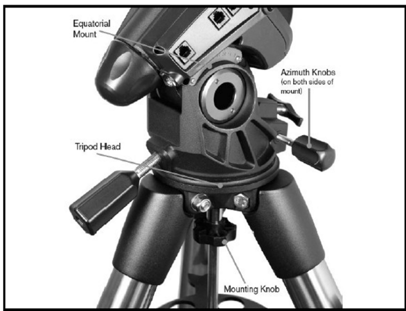


Fig 1

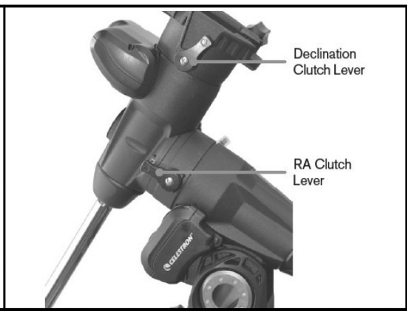


Fig 2

Fig 3:

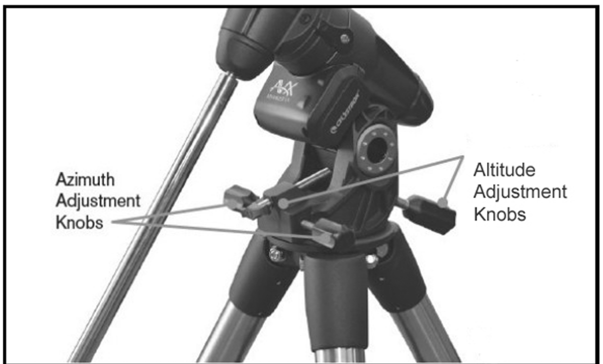


Fig 3

Time services at the Cape and Sutherland Observatories

I.S. Glass, SAAO

Introduction

In the early eighteenth century at the Cape, a bell was rung at the Castle at certain hours and provided the nearest thing to a time service. The hours were timed by an hour-glass and checked against a sundial at noon, so that it was effectively local solar time (Mentzel, 1785)[2].

An important requirement of the Cape Observatory after it was founded (1820) was the provision of precise local time so that passing mariners could set and rate their chronometers (if they could afford to own any!). A comprehensive account of time signals in South Africa has been given by Kinns (2021). For various reasons, time has continued to be an important part of the Observatory's activity. There are frequent mentions in the Annual Reports of the Royal Observatory and in various items in the SAAO Archives (such as Box A0527).

The Nineteenth Century

Information from the master clock of the Observatory had to be made available somehow to ships' captains. The way that the first director, Rev Fearon Fallows, achieved this was to appoint, in December 1821, a local watchmaker to receive the time from him, presumably by means of a portable chronometer, and a ship's clock could be brought to this person to be set and perhaps have its rate[3] determined (Warner 1995). The potential for the introduction of errors by intermediaries was obvious and later (1823, according to Warner 1979, p10) an Argand oil lamp (*ca* 10 candle power) was doused at a particular time, though it is not clear whether this became a regular service. Given that the temporary observatory was at least 1½ km from the anchorage, the light must have been very feeble and only visible through a telescope. This service to shipping was in addition to the precise time needed internally at the Observatory for the determination of Right Ascensions.

[2]Local time is based on the highest position of the Sun on each day. Mean Time allows for the non-circularity of the Earth's orbit around the Sun so that clocks can run at a constant rate year-round.

[3] Even the best clocks run fast or slow and the rates with which they do this need to be allowed for. The best clocks have constant rates, ie they do not show erratic variations. Warships often carried several chronometers so that if one of them became erratic its reading could be ignored.

Fig 1: Flare pistol used for time signalling from 1833 (SAAO Inv. M067).

For many decades the Observatory's internal time service was based on regulator[4] clocks by Hardy and Molyneux whose performance was constantly monitored. The permanent observatory in what is now Observatory suburb was operational by 1828. It was visible to vessels at anchor in Table Bay so, in 1833, Thomas Henderson, the second director, introduced signalling by means of a flare pistol fired from the roof at a particular time.

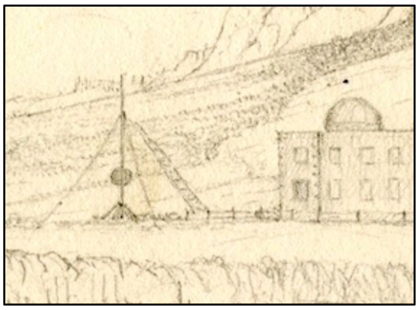


Fig 2: The first time ball at the Royal Observatory, part of a drawing by Sir John Herschel in 1837 (National Library of SA, Cape Town Map Room ARP2 (9183).

The Time Ball method for transferring time was introduced to the Cape by the third director, Thomas Maclear, in 1836, the first one being SE of the Observatory. At that time, the Observatory was visible from the Bay. This was the first of a number of balls in the Observatory, at Table Bay and indeed around the country (and Rhodesia - Zimbabwe).

Fig 3: The last time ball on the RO Site. 1863 – ca 1933 (SAAO P7241).

From 1861 they were electrically controlled by telegraph from the Observatory. This service was provided until 1 February 1934, by which time radio was common on ships. However, time signals of various kinds continued to be distributed to outside users by wire for many years, the last of them in 1971 (see below). The clock in the red Clock Tower at the Waterfront was also controlled from the Observatory.

There is still a traditional noonday gun, fired since 1807, originally from the Imhoff Battery between the Castle and the sea. Whatever clock was used initially to time this event was probably dependent on basic observations made by a member of the military and, later, on the visual signals from the Observatory. Evans (1993) has chronicled the guns and the time balls in detail.

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[4]A "regulator" clock is a particularly accurate one, built to a better standard than typical, often used for checking other clocks.

Fig 4: Time Ball tower in Cape Town docks. The Canary Islands Dragon tree nearby is no longer there (SAAO P2309).

With the coming of the telegraph, it was set off electrically from 1864. The Imhoff battery was demolished in 1896 and the guns were moved to the Castle. The time gun has been fired at the Lion Battery on Signal Hill since 1902. The history of the actual noonday gun(s) is given by Bisset (1984). Those in current use were cast in the Bahamas during the reign of George III (1760-1820).

David Gill's History (1913) shows that the time service was an important activity that from Edward Stone's directorship (1870-1879) onwards was looked after by George (son of Sir Thomas) Maclear until 1893. He was succeeded by Robert Pett (retired in 1919). It appears he was followed by Leslie Davis. In late Royal Observatory times and the early SAAO, Drummond Laing had this task. Before telegraphic and radio time signals were available, the basis of time was the rotation of the Earth and calibration was accomplished astronomically. The Observatory's regulator clocks had to be wound weekly and their rates monitored. After a certain interval they would have to be cleaned and lubricated with special oil.

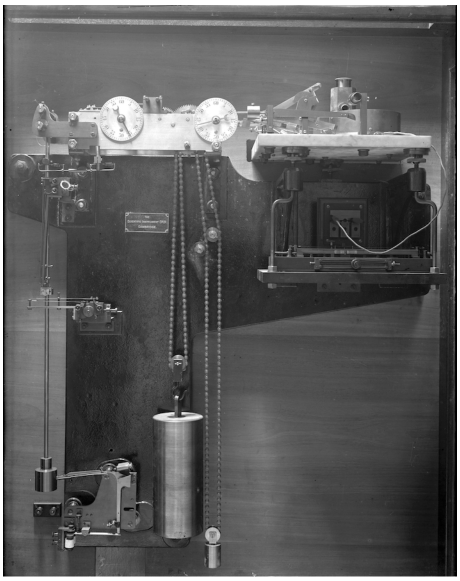
Coordinated Universal Time (UTC), that in normal use today, is set by International Atomic Time (TAI), adjusted occasionally from UT1 or Universal Time (Solar Time) defined by the Earth's rotation. It occasionally requires corrective "leap seconds" to be inserted. The defining agency is the International Telecommunications Union. However, before 1892 time all Cape Observatory signals were on local mean time. After 1892, because of the need of the railway system for uniform time, the standard of the Colony was set as mean time on the meridian of 22½° E of Greenwich and, some years after that (from 1903), to 2 hours East of Greenwich (or Universal) time (Gill, 1913) as at present. The electrical signals required were derived from platinum contacts retrofitted to the regulators and the time balls at more distant harbours were controlled through telegraph wires.

In addition to the Hardy and two Molyneux clocks, Dent Regulators Nos 2013, 2004 and 39714 have been at the Observatory since the 19th century. All of these but Dent 2013 have extra holes in their faces, probably to do with electrical contacts that were once fitted to them. These were used to generate mean time and sidereal time pulses as well as certain other signals to distribute to the various domes and items such as chronographs, telescope controls, the Noonday Gun and Timeballs that required them.

Fig 5: L-R The dials of the Hardy (case hood removed), Molyneux and Dent (No 2004) regulator clocks (From SAAO Museum Catalogue M221, M223, M228 resp.).

Dent 2013 is built into the wall of the McClean telescope and has a wooden rod pendulum (Dolan Art 1332). No 2004 stood in the corner of the Astrographic dome for a long time. Dent No 2013 was mentioned from 1880/81 in the RGO reports as being at the Cape and so was Dent No 1916 which was returned to RGO in 1971 (Dolan Art. 1332).

Gill, the 5th director of the Royal Observatory, was determined to produce the ultimate pendulum clock. Hope-Jones (1940) is one of the few sources of information about this clock, its sound principles, and the reason for its failure, related to contacts problems. A working model was constructed by the Cambridge Scientific Instrument Company and shipped to the Cape in April 1903. It was invoiced for £846-11-6 and installed in the clock room (See SAAO Archives A0047 p192 *et seq*). It had a master-and-slave design somewhat similar to the later Shortt type of clock. The "master" was completely enclosed in glass (presumably for vacuum) and, though not shown in the attached photo, a constant temperature water jacket.



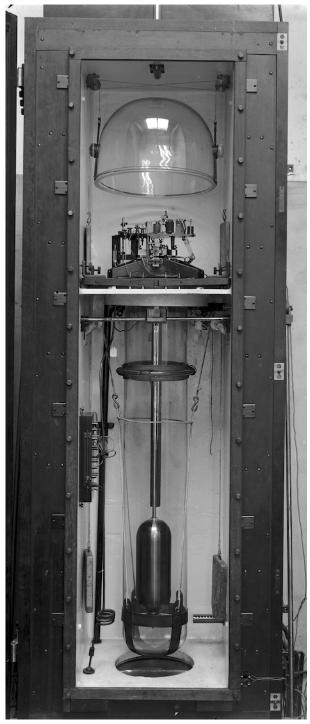


Fig 6: Left: The Gill clock (slave pendulum part) SAAO-box_09-0045.

Fig 7: Right: The Gill experimental clock (free pendulum part) SAAO-box_09-0049.

This clock never ran reliably. Many years later, following enquiries from the Cape, the then Astronomer Royal Harold Spencer Jones (1950) authorised its scrapping. Apparently Gill had hoped that his successor would continue to work on it but it was soon abandonned, to his great disappointment.

The Twentieth Century

The twentieth century saw many developments in the time services. Not only were regulator clocks constructed on new principles, but international time comparisons by radio soon became routine.

Fig 8: "Crystal set" radio receiver probably around 1914. The sliding apparatus was a "loose coupling unit", a sort of input tuner (Photo: SAAO-box_11–0011).

The Observatory had two clocks by Sigmund Riefler (Munich). Clock No 150 was made in 1905 and supplied in 1907. No 150 was sold to an American private collector in 1966 (see below). It has recently (2024) been for sale again by "The Regulator Clock Company".

Fig 9: Riefler clock number 150, formerly at RO Cape (Photo courtesy of Jonathan Flower, The Regulator Clock Company, Shropshire, UK, 2024).

The Riefler clocks dispensed with traditional heavy driving weights and instead made use of a remontoire of just a few grams, reset about twice per minute by an electromagnet. Those at the Cape were enclosed in evacuated copper containers surmounted by glass domes, though some other Riefler clocks were not so enclosed.

The other Riefler clock (no 152, made 1905, now in the Royal Museums, Greenwich, rmgc-object-79648) was installed at the Cape Observatory in 1911. See Fig 12 below[5].

The Observatory clocks were compared for longitude determination purposes against Greenwich time, one early method being by transporting multiple chronometers and a later method (1881) being by telegraph. Radio calibration was used in 1926 (Horrocks,

[5] Yet another Riefler clock, but of a type without the enclosure, is on display in the SAAO Museum. However, it was originally at the Johannesburg Observatory and was inherited by SAAO around 1972.

1929) and afforded accuracy to within a few msec, limited by shortwave propagation conditions.

Fig 10: Undated image of the clock room, probably as it was before the introduction of the Shortt clocks. Dent 39714 on left (SAAO P4827). The middle clock is Dent 39714. On the right is one of the Molyneuxs.

Radio time signals for shipping were generated by the Royal Observatory and sent via the maritime radio station at Slangkop from 1914 and were also sent to local radio broadcasting stations (from ~1925).

In 1928 a “Belin apparatus” was installed to generate standard “ONOGO” time signals to be sent by radio from Slangkop. This had been obtained at the expense of the Union Government. (Spencer Jones, 1926). It replaced the system in use since 1914. The Belin apparatus was developed by Édouard Belin and is described by Berget (1914). It appears to have contained rotating cams phase-locked to the clock, operating contactors at specific times.

Fig 11: Right: The Belin time signal generator (1928) with clock by Leroy, calibrated initially from Dent clock No 2004 (SAAO P8361).

Fig 12: Two Shortt master pendulums and Riefler 152 in the Clock Room (SAAO P4843).

Mention is made by Dolan (Art. 1327) and also Spencer Jones (1926) of Synchronome-Shortt 10 being supplied to the Cape in March 1926. A Synchronome-Shortt clock consisted of a “free pendulum” master in a vacuum container that was linked to a slave unit for display. This type of clock was regarded as the most accurate available before crystal clocks. About 100 were built ultimately and were widely used in observatories worldwide. Short 10, and the two Rieflers were used for standard sidereal time (Spencer Jones, 1933). A system for temperature control was installed in the clock room during that year.

A second Shortt clock, No 27, operating on Mean Time, was provided in 1929 by the Union Government and tested at RO Greenwich because Dent clock 2004 was not considered to have a good enough rate to use with the Belin apparatus (Spencer Jones, 1929). Further, Dolan (Art 1327) mentions "Loan of Shortts 66 and 67 to the Cape and the sending of Shortt 10 to Herstmonceux" in 1959. There are images of the Slave clock of Shortt 67 in Dolan (Art 1332). These clocks were at the Abinger station of the RGO as part of the backup time service during World War 2 (Dolan Art 1287).

Fig 13: Laurie Brown (instrument maker) with the Synchronome-Shortt slave clocks in the Clock Room ca 1960. The clock in the background behind Brown's shoulder appears to be a Riefler but its serial number cannot be read (SAAO P7962).

Fig 14: Laurie Brown with the time setup refererred to in the 1966 report. Two of the Dent regulators are seen on the right. The tape device was probably a type of chronograph (ca 1960 SAAO P7949).

According to a Memo "The Cape Time Service", probable date 1957 (Anon 1957), the Observatory was putting out ONOGO signals at 1000 and 1900 SAST to the radio station at Slangkop, a six-pip signal every quarter hour for telephone time enquiries and the SABC, a single dash each hour for telegraph and railway clocks and for firing the noonday gun. It was proposed at that time to end the ONOGO signals and replace them with a more modern code. Though the Union Government had provided the ONOGO apparatus and associated clock in 1926, the British tax payer had to pay for the full time service of one officer! Leslie Davis, who had been in charge of the time service for many years, was due to retire in 1958. Both Mean and Sidereal[6] times were displayed on Gent repeater dials in the individual domes since 1958.

[6] Whereas Mean Time is based on the rotation of the earth below the Sun, Sidereal Time is based on the rotation of the earth below the stars. They differ by about one part in 365 because of the revolution of the earth around the Sun.

The Dept of Posts and Telegraphs introduced a "Speaking Clock" in 1957.

The ONOGO apparatus was declared obsolete around December 1963 (SAAO Archives A0047). SAAO Archives A0187 mentions the attempted sale of Riefler Nos 150 and 152 in 1966-67. Number 150 was disposed of to a Dr William Vint in the USA and, as mentioned above, has since been sold again.

Dolan (Art 1287) lists the current location of Shortts 66 (sidereal) and 67 (mean solar) as the British Horological Institute (Museum of Timekeeping). It is not known what became of Shortt 27, the Leroy clock and the ONOGO apparatus (which had been provided by the South African government, as mentioned)[7].

"The pendulum clock installation has been completely replaced by two quartz crystal oscillators previously in use at Greenwich and Abinger. The time service has been operated from these oscillators since June 1962, and on January 1, 1963 the former ONOGO shipping signal was replaced by one having the standard English form" (Stoy, 1963).

Time sounders were provided in the domes in 1963-64 (Stoy, 1964).

In 1966 a "Report on Clockroom Equipment" (Back, 1966) confirms that the Cape Observatory was no longer dependent on mechanical clocks but was using the quartz crystal oscillators. However, several components were considered obsolete and unreliable. This report was probably the stimulus for providing the 1967 installation (see below). The conversion from mean to sidereal frequency was mechanical, involving a "phonic motor". The Astrolabe (a visiting instrument) and the printing chronograph of the Reversible Transit Circle required a 1-second pulse.

In 1967 a new set of time service electronics, constructed at the RO Greenwich, was installed in Cape Town (see Fig 15) in the former Steavenson telescope building. Henry Gill and Ray Foord from RGO came out for this project (Stoy, 1967). It was moved later to the "1896 building". In part, it made use of electro-mechanical components.

Time services at Sutherland

Following the merger of the Royal Observatory and the Republic Observatory into SAAO in 1972, a new time service system was built at the SAAO electronics workshop and

[7]The last mention of them found in the SAAO Archives was a letter (in Box A0196.8, R.H. Stoy to G.A. Harding 9 December 1969) stating that were sent for exhibition to the General Botha Naval Academy Museum in Gordon's Bay but a recent enquiry there drew a blank.

installed on the plateau at Sutherland. Calibration of the time came from the ZUO signals until about 1990 when that station appears to have closed down. However, WWV was still available. This system remained in service until 24 November 1993.

Fig 15: Mr Willy Pearson (electronic technician) at the Cape Observatory Time Service installation of 1967 with crystal-controlled clocks. In 1970, according to Laing (1970), time was then being provided to Cape Town Radio for shipping, to the Post Office for its Speaking Clocks and to the South African Broadcasting Corp (SAAO P2322).

The service generated nine separate signals, such as mean & sidereal times, as well as minute, second & 1kHz pulses on mean time. These were multiplexed and distributed by wire to the domes. Precise timing had become important for high speed photometry and other on-line equipment controlled by Nova mini-computers and later PC-ATs in each dome. The display units were designed by Don Taylor.

Fig 16: Drummond Laing (astronomer) checking the Sutherland time service of ca 1972 (SAAO P8084).

The next central time service at Sutherland (installed 5 October 1993) was a PC-based system with a mean time oscillator (ageing rate 1 X 10-9 per day) locked to signals from a GPS receiver once each minute. Inbuilt software was chosen to provide direct access to the on-board satellite atomic clocks and thus potentially nanosecond accuracy. The resulting drift was no more than 1-2 microseconds per minute under normal conditions. Sidereal time is calculated from the mean time. Frequent damage from lightning made it necessary to switch to fibre optics for the conections to the domes, which Geoff Evans designed. The same display system was used as previously but with updates to its software. A second identical version of this time service was made for Cape Town, with the addition of the Noon Gun and Time Ball (see Figs 17 & 18) that used the same circuit cards configured differently via jumpers.

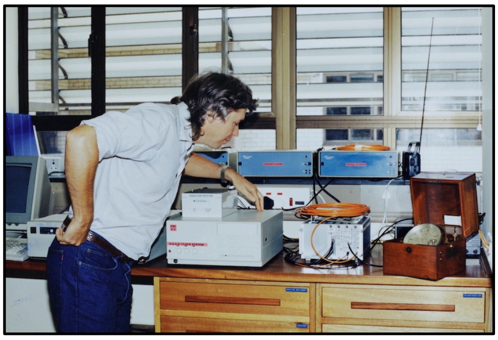


Fig 17: The late Geoff Evans (electronic engineer) with the 1993 time system under test (SAAO P2368). The blue units are modems connected to Post Office lines for driving the Noonday Gun and the Harbour Time Ball (which however remained unused). A small unit (under arm) is the "SABC 6-pips" detector designed by Mr Piet Fourie. It turns out that the transmission of SABC signals from Johannesburg to Cape Town caused a delay of around 300msec.

Fig 18: The 1993 Time Service as installed in Cape Town (Photo: W. Koorts). Black display and interface units similar to that in the middle of the figure were placed in each dome or other user installation.

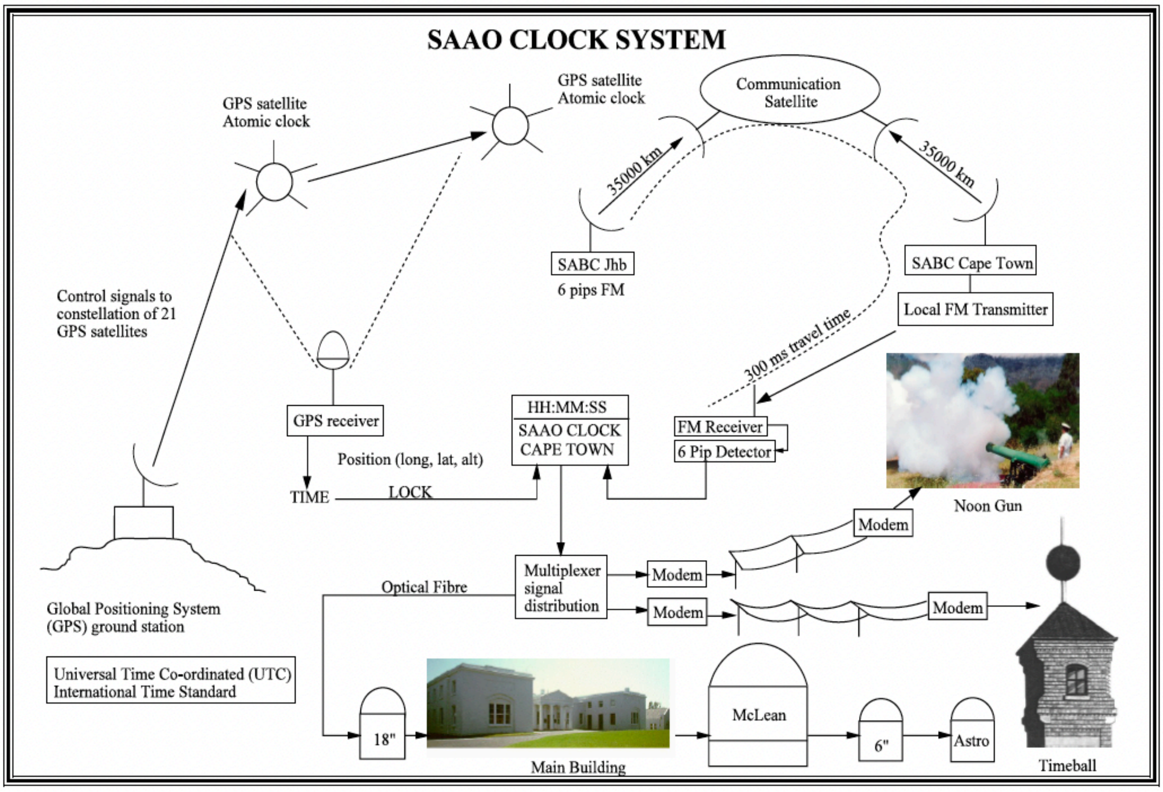


Fig 19: Outline diagram of the 1993 Time Service. The time pips broadcast in Cape Town were actually about 300 msec late mainly because the signals were sent from Johannesburg via a satellite link.

21st Century

Since 2017, NTP (Network Time Protocol) has offered a relatively easy method for individual computers to obtain millisecond accuracy over the Internet. The Sutherland computers now rely on this system but with the addition of a commercial time server at the SALT telescope. The latter makes them less than totally reliant on the Internet.

Fig 20: The last model (2017) SAAO Time Service unit (Photo: W Koorts). Each installation had its own GPS receiver but only the Noonday Gun still uses it today.

A curious situation arose over "Y2K" because the PC system was not year 2000 compliant and in 1999 Chantal Fourie had the task of upgrading the software for both Cape Town and Sutherland. The PCs did not then have hard drives and the software was on floppies. Part of this project was to replace the floppies with stiffies (South African term for the 3½-inch discs). The PC system used to send a signal at 13h00 daily to drop the timeball at the V&A Waterfront even though they did not raise it at the time. She also re-programmed the system to send signals to both the Noon Gun and the Time Ball at midnight on 1 January 2000 because this formed part of the new millennium celebrations arranged by the City of Cape Town! The upgrade was completed in July 1999.

The noonday gun on Signal Hill, near the harbour, is no longer fired from the Observatory but is now timed directly from GPS satellites by a receiver on-site, supplied by the Observatory!

Fig 20: *The daily firing of the noon gun was opened to the public from February 1997 so they could witness the oldest guns in the word still in daily use. The two guns are fired alternately, with the second being the backup, should the "duty" gun misfire (Photo by the late Geoff Evans, courtesy of W Koorts).*

Appendix: Brief mention: Time at other observatories in South Africa

The Durban Observatory ran a time service based on a Kullberg regulator clock (now at SAAO:Museum Cat. No. M236) *ca* 1882-1912. This clock is now at SAAO. See Gray (1978) for details.

Meanwhile the Transvaal (later Union and later still Republic) Observatory in Johannesburg set up a time service in 1908 based on a Dent regulator and this was improved in 1912-1914 with additional regulators by Riefler. They checked the time astronomically by means of a Bamberg "Universal Instrument" (Now in the SAAO Museum: Cat. No. M156) until 1924 when European radio time signals could be received regularly. From 1946 they had their own quartz crystal-controlled clocks and in 1966 they acquired caesium-beam atomic clocks. From 1949 they provided time signals via the dedicated radio station ZUO (Vermeulen 2006).
The Union (later Republic) Observatory seems to have sent time radio time signals to the national broadcaster SABC from 1927. Around 1949 continuous time signals were broadcast; a little later the station ZUO was established (Vermeulen 2006).

Standard time is needed by the radio observatories for pulsar observations but also to very great accuracy for intercontinental interferometry (Long-baseline interferometry) but this is beyond the scope of this article.

Provision of public time signals by the astronomical observatories seems to have ceased around 1971 when the Republic and Royal Observatories were merged and ceased to exist independently. Correspondence with JD Laing (SAAO) (Laing, 1972) indicates that the Time Standard Section, National Physical Research Laboratory of CSIR were then taking over the equipment formerly at the Republic Observatory and ZUO was being transmitted from Olifantsfontein. By 1979 they were the national agency for maintaining time standards in conformity with the international system UTC (Lake & Turner, 1979).

Ca 1983-1985 a system of time transfer using the SABC-TV service was introduced (see correspondence etc in SAAO Archives A0379).

The South Africa standard time is maintained at the time of writing (2024) by the Time & Frequency laboratory of the National Metrology Institute of South Africa.

Acknowledgments Willie Koorts and Chantal Fourie are thanked for providing information about the most recent SAAO time services. Graham Dolan kindly furnished information about the RGO involvement.

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Colloquia

Colloquia and Seminars (now Webinars) form an important part of a research facility, often as a sort of pre-publication discussion or a discussion of an individual's current research, and as such it is virtually impossible to "publish" this material. However by recording the topics discussed in the form below does indicate to those, who are unable to attend, what current trends are and who has visited to do research: it keeps everyone 'in the loop' so to speak

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With the passing of CV19, these Colloquia and Seminars are returning slowly to their normal face-to-face format, but a spin-off from the pandemic is that Colloquia and Seminars are often Hybrid sessions. It has also meant that now these Webinars on interesting topics from around the globe! The editor however still focusses very much on sessions held locally, by South African astronomers or visitors to South Africa.

Title: The CRAFT survey, and exploring the environments of fast radio bursts
Speaker: Dr Marcin Glowacki
Date: 1 March 2024
Venue: UWC Room 1.35 and Zoom
Time: 11h00

Abstract: The Australian Square Kilometre Array Pathfinder (ASKAP) is one of the leading fast radio burst (FRB) detection and localisation telescopes. On behalf of Commensal Real-time ASKAP Fast Transients (CRAFT) Survey team I will present an update on recent results and upcoming upgrades. Localisations of FRBs to their host galaxies with <1 arcsecond precision have been steadily increasing, which have been combined with dedicated optical imaging and spectroscopic follow-up primarily on the ESO VLT. These new FRB localisations, together with previous CRAFT localisations, have been combined with analysis of the high time resolution (3 ns) polarization data. This unique time resolution enables an improved structure maximisation of the dispersion measure, and to place constraints on the positions of scattering screens along the FRB path. I will also present work I have led in exploring the neutral hydrogen content of

FRB host galaxies, and the first redshift measurement for such an FRB system using radio observations.

Title: A new measurement of the mass-spin relation: a tool for understanding galaxy formation and evolution
Speaker: Dr Ed Elson University of the Western Cape
Date: 07 March 2024
Venue: SAAO Auditorium
Time: 11h0

Abstract: The galaxy mass spin relation is a sensitive probe of the processes by which galaxies acquire mass in a Lambda-CDM universe. It allows measurements of the baryonic components of galaxies to be linked to their dark matter properties. In recent years several measurements of the mass-spin relation have shown it to be well-described by an unbroken power-law over several decades of stellar mass. While there is a general consensus that the power-law index is close to 2/3, additional measurements of the relation based on larger samples and accurate measurements of galaxy properties are needed to better refine the relation. In this presentation, I will present the results of a study that has yielded what is arguably the best measurement of the mass-spin relation to date. Strong evidence is found for a galaxy's concentration of stellar mass (as quantified by its I-band effective surface brightness) serving as an important secondary driver of its angular momentum content

Title: The Cosmological Principle and the kinematic dipole
Speaker: Prof. Chris Clarkson
Date: 07 March 2024
Venue: UWC Room 1.35
Time: 11h00

Abstract: The Cosmological Principle is part of the foundation that underpins the standard model of the Universe. In the era of precision cosmology, when stress tests of the standard model are uncovering various tensions and possible anomalies, it is critical to check the viability of this principle. A key test is the consistency between the kinematic dipoles of the cosmic microwave background and of the large-scale matter distribution. Results using radio continuum and quasar samples indicate a rough agreement in the directions of the two dipoles, but a larger than expected amplitude of the matter dipole. The resulting tension with the radiation dipole has been estimated at $\sim 5\sigma$ for some cases, suggesting a potential new cosmological tension and a possible violation of the CP. However, the standard formalism for predicting the dipole in the two-dimensional projection of sources overlooks possible evolution effects in the luminosity function. In fact, radial information from the luminosity function is necessary for a correct projection of the three-dimensional source distribution. Using a variety of current models of the quasar luminosity function, we show that neglecting redshift evolution can significantly overestimate the relative velocity amplitude. While the models we investigate are consistent with each other and with current data, the dipole derived from these, which depends on derivatives of the luminosity function, can disagree by more than 3σ. This theoretical systematic bias needs to be resolved before robust conclusions can be made about a new cosmic tension.

Title: New insights into active galaxies, via their radio emission
Speaker: Dr. Sarah White (SAAO)
Date: 15 March 2024
Venue: UWC Room 1.35
Time: 15h00

Abstract: Radio observations allow us to identify a wide range of active galactic nuclei (AGN), which play a significant role in the evolution of galaxies. However, when it comes to studying their properties as a function of redshift and/or environment, the most-detailed studies tend to be limited by small-number statistics. In the first part of this talk, I will describe the G4Jy Sample (White et al. 2020a, 2020b; https://github.com/svw26/G4Jy) -- a collation of the brightest radio-sources in the southern sky (Dec. < 30 deg) -- whose bright emission is detected at low radio-frequencies using the Murchison Widefield Array. This instrument is the precursor telescope for the low-frequency component of the Square Kilometre Array, and allows us to select radio galaxies in an orientation-independent way (i.e. minimising the bias caused by Doppler boosting, inherent in high-frequency surveys). 140 G4Jy sources have been observed using Open Time on MeerKAT (PI: White; Sejake et al., 2023), and I will also describe follow-up using ATCA, the VLA, and SALT. With over 10 times as many sources as the best-studied, low-frequency radio-source sample that is optically complete (the revised Third Cambridge Catalogue of Radio Sources; 3CRR), the G4Jy Sample will allow models of powerful AGN to be tested more robustly. For the remainder of my talk, I will present analyses of radio emission from 'radio-quiet' AGN. Being at low radio-luminosities, it has been assumed that their emission is dominated by star formation, but previous multiwavelength analyses (White et al., 2015, 2017) led to controversial evidence that black-hole accretion makes a significant contribution towards the total radio emission from this type of AGN. Due to the greater level of sensitivity that MeerKAT provides, we are able to detect a larger fraction of star-formation-related radio emission (White et al., in collaboration review), with further analysis being required (White et al., in prep.). These studies have important implications for modelling AGN feedback, and for determining the accretion and star-formation histories of the Universe.

Title: Five Surprising Results From the Simba Simulations
Speaker: Prof. Romeel Davé Institute for Astronomy, University of Edinburgh, Royal Observatory, Blackford Hill, Edinburgh EH9 3HJ, UK and University of the Western Cape, Bellville, Cape Town 7535, South Africa
Date: 15 March 2024
Venue: UWC Room 1.35
Time: 11h00

Abstract: Cosmological simulations of galaxy formation have matured rapidly in the last few years, with recent models combining structure formation, hydrodynamics, stellar and black hole growth, and associated feedback processes to accurately reproduce key demographical properties observed in the galaxy population. But the input physics required to do so can have unexpected consequences in disparate regimes that run counter to conventional notions of how galaxies form and evolve. In this talk I present our Simba simulations, a state-of-the-art suite that uses novel approaches for modelling black hole growth, AGN feedback, and dust to yield a galaxy population that uniquely reproduces some observations. I will further discuss how Simba offers some surprising predictions on how galactic feedback processes interact with and impact their larger-scale cosmic ecosystems that could be tested with facilities such as MeerKAT.

Title: 21cm Cosmology: tracing neutral hydrogen across cosmic time
Speaker: Dr. Marta Spinelli Observatoite de la Côte d'Azur (OCA)
Date: 15 March 2024
Venue: UKZN
Time: 15h00

Abstract: The redshifted 21cm line of neutral hydrogen (HI), detected by radio telescopes, can probe back to the Cosmic Dawn when the Universe was only hundreds of million years old and up to the late Universe and the large-scale structure. This makes the 21cm one of the most promising observables to map the evolution of the Universe, with the potential of transforming our understanding of cosmology and baryon physics. In this talk, I will discuss two different subjects in 21cm cosmology: total-power radiometry with individual meter-wave antennas as a potentially effective way to study the Cosmic Dawn and 21cm Intensity Mapping with the SKA Observatory precursor MeerKAT for the study of dark matter and dark energy in the post-reionization era. For

both, a key challenge is the subtraction of the bright foregrounds, orders of magnitude stronger than the 21cm signal. It is therefore crucial to understand the systematics in the data and assess our ability to isolate the pristine cosmological signal in realistic scenarios through simulations. I will review the problem for the different experiments and present a brief state-of-the-art overview. I will then conclude by discussing the road map for the era of the SKA Observatory.

Title: Probing for optical and HI diffuse gas in MHONGOOSE galaxy UGCA 250
Speaker: Mikhail De Villiers UCT and SAAO
Date: 04 April 2024
Venue: SAAO Auditorium
Time: 11h00

Abstract: Extraplanar diffuse ionised gas (eDIG) has been observed in external spiral galaxies as well as the Milky Way and is distinguished by its emission-line ratios and its rotational velocity lag with respect to the galactic disk. Similarly, there is a wealth of observational evidence for extraplanar gas in the form of neutral atomic hydrogen (HI) associated with spiral galaxies.

MHONGOOSE is an HI Nearby Galaxies Legacy Survey of MeerKAT probing the neutral atomic hydrogen in and around local disk galaxies. UGCA 250 is an edge-on, late-type spiral (Sd) galaxy part of MHONGOOSE. This work searches for signatures of extraplanar gas associated with this galaxy through studying the kinematics of the HI using tilted-ring modelling and Gaussian decomposition. This is supplemented with high-resolution spectroscopic data from the Southern African Large Telescope (SALT) allowing for the detection of extraplanar gas in both its ionised and neutral states. We find interesting kinematics in both the optical and the radio, suggesting that the kinematics should be explained by more than a simple disk model adopted in this work. The end result is a multi-wavelength characterisation of the gas associated with this galaxy. Thus, we probe for multi-phase planar and extraplanar diffuse gas associated with this galaxy. This talk showcases how sensitive HI observations with MeerKAT can be combined with high-resolution spectroscopic SALT data to achieve a complete kinematic study of a nearby galaxy.

Title: Navigating ASTROMOVES
Speaker: Dr Jarita Holbrook
Date: 19 April 2024
Venue: UWC Room 1.35 and Zoom
Time: 11h00

Abstract: ASTROMOVES is an EU funded project to study the career decision making and career navigation of astrophysicists and those in adject sciences. Over two years, 43 scientists were interviewed with a focus on intersectionality and gender diversity. Some of the findings will be presented for discussion including the endless postdoc cycle, impostor syndrome, precarity, maternity and negotiations. Points will be illustrated using film clips from the interviews**.**

Title: RADHIANCE: Radio-based Analysis and Detection of HI, AGN, star-formation and their Cosmic Evolution
Speaker: Dr Jacinta Delhaize, Lecturer/Academic staff at UCT
Date: 25 April 2024
Venue: SAAO Auditorium and Zoom
Time: 11h00

Abstract: I will present an overview of the work of the "RADHIANCE" research group from the University of Cape Town Astronomy Department. We use both spectral line and continuum data from South Africa's MeerKAT telescope to study various aspects of galaxy evolution. We are particularly involved with the MIGHTEE and LADUMA large survey projects. The RADHIANCE group aim to understand the role of both (i) neutral hydrogen gas content and (ii) AGN activity, on the evolutionary pathways of galaxies. We examine how gas content and AGN activity are connected, the influence they have on star formation, and how this changes with cosmic epoch. I will present selected results from our work, including:
- The discovery and properties of giant radio galaxies (GRGs) in MIGHTEE
- Attempts to push the sensitivity limits of HI detection in MIGHTEE
- The first HI detections in LADUMA

Title: NEVO: illuminating the dark cosmos
Speaker: Dr Farbod Hassani Institute of Theoretical Astrophysics, University of Oslo,
Date: 03 May 2024
Venue: UWC Room 1.35 and Zoom
Time: 11h00

Abstract: The Universe has entered an accelerating expansion phase in the last few billion years of its evolution, a phenomenon that is caused by the mysterious entity known as dark energy.

To understand the nature of dark energy, we must carefully investigate different candidates and observe how they affect the Universe at various stages. Then we may utilize data to select the best candidate. However, the consistent and accurate modelling of dark energy candidates has been largely neglected so far due to significant

challenges, including the absence of relativistic N-body codes, the immense computational costs involved, and the limited availability of relevant data to date. To address this gap, we have proposed the development of a novel framework, called NEVO, that utilizes state-of-the-art “relativistic” N-body simulations along with the advanced Boltzmann codes, to accurately model dark energy candidates in both linear and non-linear scales.

In this presentation, I will go into detail about the recently awarded NEVO proposal and discuss its challenges in depth.

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Publications: The Society publishes its electronic journal, the *Monthly Notes of the Astronomical Society of Southern Africa (MNASSA)* bi-monthly, the annual *Sky Guide Southern Africa*.

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