Tailpiece

Advertisements

This space is available free to members for advertisements (preferably, but not necessarily astronomical).

Where are we?

Astronomers need to know where on the Earth they are, in order to get accurate predictions of the positions of celestial objects, and for reporting observations. When we established the Astronomy Section's Observatory some years ago we calculated its latitude, longitude and altitude by studying the Ordinance Survey map of the Island. We obtained:-

Latitude	49° 26' 57"	North
Longitude	002° 38' 08"	West
Altitude	47 metres	

Recently, Section member Sean Harvey, who is a surveyor in the States Department of Engineering, carried out a survey to establish the Observatory's position (centre of the main building) more definitively. His results, in the UTM Zone 30 grid system were:-

Latitude	49° 26' 57".3895	North
Longitude	002° 38' 08".8610	West
Altitude	46 metres	

and in the New Guernsey Grid system:-

Latitude	49° 26' 53".9944	North
Longitude	002° 38' 13".1833	West
Altitude	46 metres	

He also determined the declination of the building, ie the angle by which it differs from a north-south direction. It is:-

South, declining east 008° 45' 55"5 ± 30"

Many thanks, Sean. ☆

Astronomy Section Officers

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The next newsletter will be published early in November. The deadline for publication copy is the 15th October.

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Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

September/October 1997

Forthcoming events

Total lunar eclipse
Tuesday 16th September
7.00 pm at Jerbourg car park

The Hubble Space Telescope
Professor Alec Boksenberg
Wednesday, 1st October
8.30 pm at
the Duke of Richmond Hotel
(optional dinner at 7.00 pm)

Video Evening and Star Night
Tuesday, 14th October
7.30 pm at La Houguette School

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What happened to Vulcan?
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US Naval Observatory
Astronomical crossword

Inside

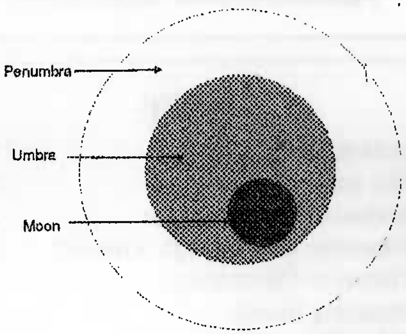
Centre inserts

Star chart
Moon phases
Sunset, twilight and sunrise times

Total lunar eclipse

Moonrise on **Tuesday, 16th September** is special, as the rising Moon will be well into a total eclipse. **We will be meeting at Jerbourg car park at 7.00pm**, ready to watch the event. The Moon will rise at 7.19pm, 11 minutes after the start of totality. Mid-eclipse is at 7.46pm and totality ends at 8.17pm. The umbral part of the eclipse concludes at 9.45 pm.

This eclipse is at a much more sociable time than the last two, which have been in the early hours of the morning. We can therefore expect public interest in it, and we will, in fact be encouraging the public to join us at Jerbourg to watch it. We will be taking the 11-inch Celestron, and hope to have a number of telescopes there. Please bring along your telescopes and binoculars.



Mid-eclipse

This eclipse gives a great opportunity for viewing the blood-red eclipsed Moon as it rises. It is also an opportunity to educate people about eclipses. If it is clear we can expect a good crowd. As many Section members as possible are needed to assist with this event.

See you there! ✩

Hubble talk

There is a special opportunity to hear a renowned astronomer talk about the Hubble Space Telescope in October. Members have been invited to attend the meeting of the the Channel Islands Group of Professional Engineers to be held **at 8.30 pm on Wednesday, 1st October at the Duke of Richmond Hotel, when Professor Alec Boksenberg, CBE FRS of Cambridge will be talking about the Hubble Space Telescope.**

The HST is the most precise astronomical facility yet constructed. Unhampered by the optical limitations imposed by the Earth's atmosphere, its imaging quality and pointing stability greatly exceed what has been achieved with ground-based telescopes.

Professor Boksenberg's lecture will describe the technical approaches adopted to meet the HST's challenging performance specification. Some of the most exciting astronomical discoveries obtained to date will be described and interpreted. These will include aspects of the Solar System, how stars in our galaxy are formed and evolve, the nature and formation of galaxies and quasars, and the evolving large-scale properties of the universe.

There is an optional dinner at 7.00 pm prompt before the lecture, at a cost of £13.00 per person. If you want to attend the dinner you must inform David Le Conte, and pay the amount due (cheques made out to CIGPE) no later than Saturday, 30 September.

Anyone planning to attend the lecture is also asked to inform David in advance, so that we can give the CIGPE an idea of the numbers attending. ✩

Video evening and star night

Our annual public video evening and star night starts **at 7.30 pm on Tuesday, 14th October at La Houguette School.**

This year our main video is likely to be *Cosmic Voyage*. This is a superb 35-minute film made for IMAX cinemas, specifically for the Smithsonian Institution's Air and Space Museum. It combines live action with state-of-the-art computer-generated imagery, to show where humans fit in the ever-expanding universe. The highlight is a "cosmic zoom" based on the powers of ten, extending from the surface of the Earth to the largest observable structures of the universe, and then back down into the sub-nuclear realm – a guided tour across some 42 orders of magnitude! It explores existing scientific theories, some of which have never before been visualised on film, from the birth of the cosmos and solar system to the nature of black holes and exploding supernovæ. It is a beautifully crafted film and highly recommended.

Following the video we will head up the road to the Observatory. The Moon will be bright, but Jupiter and Saturn will be visible. ✩

Interstellar molecules

On the 22nd July Chris Mahy spoke on the Search for Molecules in the Interstellar medium, and specifically the molecule C60 Buckminsterfullerene. He explained that this was "experimental astronomy", in that it was done on the ground in laboratories. His fascinating talk was divided into four parts: introduction to molecular spectroscopy, the experiments, C60, and current research in this field.

He explained that molecules could be identified through their spectra. For a long time it was thought that there was nothing between the stars, but then radio telescopes identified a long list of molecules in space. Professor Sir Harold Kroto suggested that very large carbon molecules found in laboratory experiments should be found in space, for example around red giant stars, which are surrounded by "soot". At that time (1985) a group in Texas was doing experiments on silicon compounds, bombarding silicon with a laser – a very expensive process. Kroto suggested that they use carbon, and C60 Buckminsterfullerene was discovered.

Five years later another experiment, in Heidelberg, carried out very cheaply, produced the C60 molecule in large quantities, and it is now possible to buy C60, and other large carbon molecules, by the kilogram. C60 is highly stable, and can be modified by including other molecules, to produce useful derivatives, such as super-conducting material.

Chris himself had carried out some work at Sussex University (where Kroto is), attaching fluorite to C60. He explained the value of three-dimensional computer simulations, especially as fluorite is a dangerous substance.

Chris emphasised that there had been astronomical reasons for both the experiments, namely the search for diffuse interstellar bands. What had been discovered in space was not C60 but hydrocarbons. However, it raised the interesting possibility of finding lifeforms in space, and the suggestion that life on Earth may have come from an asteroid.

For relevant web sites see page 5. ✩

Observatory Day

This year our chosen day for work at the Observatory – Saturday, 26th July – was not quite as hot as last year, which made the outside work more enjoyable. More members of the Section were able to lend a hand during the day, and a considerable amount of tidying up and clearing was achieved.

A new light for our car parking area was installed – thanks to Ken for supplying and fitting – making sure that it is 'sky friendly', to preserve our dark skies. Several repair jobs could not be completed, however, so these will have to wait for another time. One definite improvement is the Observatory's run-off roof. David fitted rollers (supplied by John Taylor), which have helped to brace the sides so that the wheels are better aligned with the tracks.

For maintenance work we do have some supplies of wood and paint at the Observatory, but in planning a work day it would help to have a get-together in advance so that we can be sure that necessary materials are available.

Many thanks to those who helped on this occasion: Roger, Ken, Debbie (and Laura), Gerald, Peter, David, Robert, and Geoff. ☆

GF

Visits to observatories

David spent three weeks travelling in the USA, including visits to no less than four observatories: the US Naval Observatory in Washington DC, Tim Puckett's private observatory in Georgia, the F L Whipple Observatory at Mount Hopkins in Arizona, and Kitt Peak National Observatorya. Accounts of these visits will appear in [illegible]. The first is on page 16. ☆

Barbecue and Perseid meteor watch

This year the 11th August was a perfect evening for the barbecue, but sadly, few Section members took advantage of the opportunity.

Soon after 10.30 pm the sky was dark enough to start keeping a watch for the Perseids, and, with the Moon near First Quarter and setting, there was not too much light to spoil the view.

There are usually at least one or two particularly bright meteors during our Perseid watch, and this was no exception. At about 10.55 pm we were rewarded with the sight of a meteor which looked really more like a firework, streaking brilliantly from the northeast. It was greenish in colour, and left a luminous trail hanging almost overhead for quite a few seconds.

The overall meteor count was not, however, particularly good, with only about a dozen noted in the space of an hour. Section member Michael Maunder, observing near his home in Alderney, also reported that the meteors seemed to be rather fewer than he had expected.

One unexpected bonus of the evening was an excellent view of Russian Space Station *Mir* passing overhead, looking almost as bright as Jupiter. The times for observing Mir are published in *Modern Astronomer* magazine (which we obtain on subscription for the Observatory). ☆ *GF*

I tried to observe the meteors from the Great Smokey Mountains of North Carolina, but was hampered by tall trees (I was in the middle of a forest!), and was fooled on several occasions by fireflies! Tim Puckett had We were divided into three groups, and my group was first

Two unusual objects

During the latter part of July there have been two unusual objects spotted in the night sky. No – they were not UFOs, but those who saw them agreed that they certainly were unusual.

The first was on the 22nd July, after Chris Mahy's talk, the time possibly about 11.00 pm. A bright star was spotted slightly to the west of due north, an area of the sky without any bright stars. it was about the brightness of Arcturus. It remained steady for several seconds, then faded and vanished. This must have been a satellite travelling in a direct line to our view, which gave the appearance of being stationary. No one saw it first come into view – it was just there.

The second object was a week later, on the 29th July, at about 10.20 pm. This was a shooting star of between magnitudes 1 and 0. It was orange in colour, and travelled west to east from under Boötes, through Ophiuchus, fading just before Capricornus, and taking about 10 seconds to do so. The most likely explanation for this "slow" shooting star is that it was a piece of space junk re-entering the atmosphere and burning up.

Did any other members see these objects? Did anyone see how the satellite first appeared? ☆

Debby Quertier

Buckminsterfullerene web sites

Following his talk on the 22nd July, Chris Mahy kindly provided the following list of internet pages giving more information about C60 (Buckminsterfullerene), and some related science.

http://www.cpes.sussex.ac.uk/facility/hwk/
http://www.ornl.gov/ORNLReview/rev26-2/text/rndmain1.html
http://buckminster.physics.sunyseb.edu/p.../node2.html
http://www.cv.nrso.edu/~wootten/allmols.html
http://buckminster.physics.sunyseb.edu/nobel.html
http://www.susx.ac.uk/Users/kroto/c60a.jpg
http://techinfo/jpl.nasa.gov/wwwr&t/94r&t/n170sp.htm
http://www.timeamerica.com/fullertech
http://www.physik.uni-stuttgart.de/ExPhy...k.thier/fullerene/fullerene_history.html
http://www.cnn.com/TECH/9604/12/extra.t.carbon/index.html
http://www.physik.uni-oldenburg.de/bucky/htmls/bucknew.html
http://buckminster.physics.sunyseb.edu/solids/novrml/c60str.html
http://www.adit.fr/PRODUITS/Tf?Anciens/TF19a.html#Ful
http://www.whitehouse.gov/WH/EOP/OSTP/Science.html/carbon.html
http://www.cv.nrao.edu/~awootten/astrophysics.html
http://dsnra.jpl.nasa.gov/IMS/

Chris says that there are also many books on the subject, and that the best one he has come across so far is by Jim Baggot called *Perfect Symmetry – The Accidental Discovery of Buckminsterfullerene* (ISBN 0 19 855790, published by Oxford University Press). ☆

WHATEVER HAPPENED TO VULCAN?
by Tom Butler

Nearly a century before Clyde Tombaugh discovered Pluto, Urbain Jean Joseph Leverrier discovered a ninth planet. No, I don't mean the eighth planet, Neptune, which he was also instrumental in discovering. But let's not get ahead of the story.

Jean Leverrier was a mathematical astronomer who may never have looked through a telescope. He discovered planets while working in his office in the Ecole Polytechnic in Paris. He had successfully predicted the position of Neptune after analyzing the orbit of Uranus, which seemed to be lagging behind its predicted position. His second discovery was Vulcan, which he predicted was orbiting closer to the Sun than Mercury.

Mercury's orbit had been giving trouble to astronomers since it was observed to rotate around the Sun 40 arc-seconds per century faster than the Newtonian laws of gravitation permitted. After his recent triumph of predicting the position of Neptune from the irregularities in the motion of Uranus, Leverrier began using his powerful analytical techniques on the problem of Mercury.

On September 12, 1859, Leverrier went before the French Academy of Sciences with the results of his calculations. He declared that the irregularities in the orbit of Mercury could be explained by the presence of a new planet within the orbit of Mercury. He named this new discovery Vulcan after the Roman god of fire.

It didn't take long for Leverrier's predication to be confirmed. Just three months after he had made his announcement he received news of an observation made by a physician and amateur astronomer nine months earlier. Dr. Lescarbault of Orgeres had been searching the Sun for more than twenty years in hopes of finding a new planet as it transited the sun's disc. He reported that on March 26 of the same year he had seen a perfectly round object crossing the Sun. He had kept his observation to himself until he could confirm the sighting with another observation. As soon as he heard of Leverrier's prediction he went public with his findings.

On hearing of Lescarbault's observations Leverrier hurried to Orgeres to confront the physician. He berated the doctor for not coming forward sooner with his observations. After seeing the physician's primitive timing instruments, consisting of a large pocket watch and a ball hung by a silk thread as a pendulum to time the seconds, Leverrier suspected the authenticity of the findings -- especially after Lescarbault could not find his original observations which he had saved on a board because he was short of paper. The plank was eventually found, and, convinced of the validity of the findings Leverrier calculated the period of Vulcan to be 19¾ days, and the distance from the Sun to be 13 million miles.

Three years after Dr. Lescarbault made his sighting an amateur astronomer in Manchester, England, made a second confirming sight of the elusive sun-hugging planet. Mr. Lummis was observing the Sun when he was ➡

astonished to see a spot moving rapidly across the face of the Sun. It was a sharply defined circular spot moving too rapidly to be a sunspot. He followed the spot for some twenty minutes before breaking off to take care of some official business. Now just what "official business" could be important enough to interfere with the confirmation of a possible new planet we must remain ignorant.

Working from the data supplied by Lummis, two frenchmen, Valz and Radau, computed the orbit of the new planet, and found essentially the same orbital constants that were found by Leverrier using Lescarbault's data. This gave strong evidence to the existence of Vulcan. But still many astronomers disagreed with the findings. One in particular, Liais by name, was the acting director of the Brazilian Coast Survey. Liais claimed that he had been observing the Sun at the same time as Lescarbault (using much better equipment than was used by the French physician), and was certain that no such object was to be seen .

The observations of Lummis were also challenged by Professor Peters in America and Sporer in Europe, who both claimed to have seen the planet-like object and identified it as a sunspot.

Leverrier examined all the evidence that was presented, and continued to declare that because of the irregularities in Mercury's orbit there had to be some object or objects between the orbit of Mercury and the Sun. He observed that it could be in the form of asteroid-like objects, a single planet or even cosmic dust. He died in 1877 still believing that Vulcan had been discovered.

The next chapter of this story concerns the "rediscovery" of Vulcan. This involved two men, Professor James Craig Wilson and Mr. Lewis Swift. Swift was a prosperous amateur astronomer who ran a hardware business in Rochester, New York. Because of his activities in astronomy, the citizens of Rochester built an observatory equipped with a 16-inch telescope, and presented it to Swift. He became well known as a comet hunter, and by the time he was 79 years old he had discovered no less than 12 comets.

Professor Watson was Director of the University of Michigan Observatory and later of the Washburn Observatory in Madison, Wisconsin. He was a well-established observational astronomer, having discovered 23 asteroids. When he died he was in the process of building an observatory primarily to support a search for Vulcan.

The total solar eclipse of the 29th July 1878 provided the opportunity for Swift and Watson to search for Vulcan by blotting out the glare of the Sun. Watson was observing in Separation, Wyoming, and Swift in Denver, Colorado. By using maps of the star-field near the Sun, the two astronomers hoped to find a planet (Vulcan), or an asteroid or a comet near the Sun that could explain the perturbations observed by Leverrier nearly twenty years earlier. The two astronomers got more than they bargained for. Instead of one Vulcan they located two objects. Swift and Watson individually claimed to have found two intra-Mercurial objects.

Although their observations stirred up a hot debate led by Dr. Peters, who had disputed the findings of Lummus, Swift and Watson held their ground as competent observers and claimed that they had definitely observed something that ➡

could be Vulcan. Their observations were made under less than ideal conditions. The obvious necessities of observing in a remote site and the short duration of the eclipse (less than three minutes) could cast doubt on the accuracy of the results.

Four years later another eclipse, visible in the South Pacific, provided an opportunity for yet another search for the elusive planet. This was of much longer duration, lasting almost 5½ minutes, and provided two astronomers, Trouvelot and Palisa, the opportunity for a more exhaustive search. However, they found nothing.

The solar eclipses of 1901, 1905 and 1908 provided further chances to confirm the existence of one or more objects orbiting within Mercury's path. But even with the new tools of photography available, the searches were in vain. Many other attempts under ideal conditions and with the best equipment failed to reveal the planet.

The long search for Vulcan began with Leverrier's computations to explain the anomaly of Mercury's orbital motion. The search ended 55 years after it began with the calculations of another mathematician at his desk in Berlin, 500 miles away. When Albert Einstein developed his Theory of Relativity in 1915, he removed the necessity of an intra-mercurial planet. This theory provided a modification to Newton's gravitational laws by just the right amount and direction to explain the slight differences in the motion of Mercury.

I often wonder if this incident might explain the rash of UFO sightings, when people see and confirm what they expect to find with their observations. ✫

Tom Butler

Tom Butler teaches astronomy at Palm Beach Community College, Florida, USA. He was formerly Director, Buzz Aldrin Planetarium, at the South florida Science Museum, and worked with optical and laser satellite-tracking at the Smithsonian Astrophysical Observatory, and was Administrator for the Multiple Mirror Telescope at Mount Hopkins, Arizona. ✫

Visitors to Observatory

We were pleased to welcome Dr Pilkington at the meeting held at the Observatory on the 22nd July. We were also pleased to see again Richard Mallett, who has previously given us talks on sundials and solar eclipses. And David Falla, who founded the Section paid a visit from Wales.

Also on the 22nd July several Grammar School students visited the Observatory, led by teacher and astronomer Glen Comery. This was part of their annual projects week, when Glen does astronomy with selected students, including observing from the south coast.

On the 24th September we are expecting about a dozen members of the Rohais Methodist Church Friendship Circle. ✫

Departing friends

In the last newsletter we reported that Daniel Cave had left the Island for England. In August, John Taylor left for the Isle of Wight. John's technical expertise will be sorely missed.

Both Daniel and John remain members of the Section, and have promised to keep in touch. We hope to see them both back in Guernsey from time to time. ✫

Calendars – Part 2

In Part 1 we looked in some detail at the history of the Gregorian calendar, including its antecedant Julian calendar. Now let us consider a few other calendars, including some no longer in use, but nonetheless of historical importance.

The Egyptian Calendar

The ancient Egyptian calendar is important to us as it was an ancestor of our present calendar. (The Egyptians also gave us the 24-hour day.) The early Egyptians used a lunar calendar, but eventually changed to a solar calendar with a 360-day year (12 months of 30 days). In the 8th century BC five extra days were added to the end of the year, to give it 365 days.

As this was about a quarter of a day less than the tropical year, the New Year moved through the seasons, with a "*sothis period*" of 1460 years. (The word *sothis* is related to the star Sirius.) However, in 239 BC the *Canopus Decree* introduced a leap year every few years.

The Egyptian New Year was dependent upon the flooding of the Nile, in early July. The *heliacal* rising of Sirius occurred a few days before the flooding. Sirius was therefore considered as a herald, and was worshipped. A *heliacal* rising is the rising of a star or planet just before sunrise. The object is seen for just a few minutes before sunlight intervenes.

It occurs at the same time each year. The star chart below shows, with due allowance for precession, the almost simultaneous rising of Sirius and the Sun, as seen from the latitude of Giza in early July in the year 8000 BC.

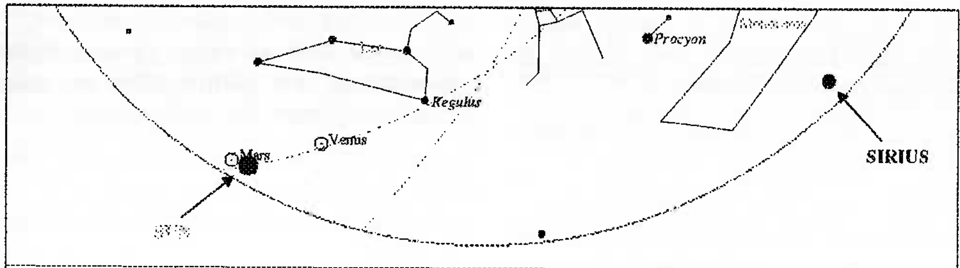
Neugebauer has suggested that *"This calendar is, indeed, the only intelligent calendar which ever existed in human history."* His reason appears to be that the Egyptian calendar facilitated astronomical calculations, because it was continuous and uncomplicated, unlike lunar calendars. Therefore, it was used by the Greeks, and was apparently even used by Copernicus in his lunar and planetary tables.

The Islamic Calendar

The Islamic Calendar is a lunar calendar, based on the lunar phase cycle. Therefore, the cycle of 12 lunar months regresses through the seasons with a period of about 33 years. In this period there are 11 leap years, giving an average length of month only 8 seconds less than the average synodic month.

Days are reckoned from sunset to sunset. The days are numbered, not named, except for the fifth day, *Jum'a*, which starts at sunset on Thursday and ends at sunset on Friday.

The month begins with the first visibility of the crescent Moon after New Moon (about 15 hours). ➠



The heliacal rising of Sirius. 1 July 8000 BC

The epoch is the date of the migration of the Prophet Mohammed from Mecca to Medina, and is taken to be 15 July AD 622 (Julian Calendar).

The Hebrew Calendar

The Hebrew Calendar is a luni-solar calendar, based on calculation, not observation as in the case of the Islamic calendar. It is based on the *Metonic cycle* of 235 lunations, which equals 19 years.

The epoch is the *Era of Creation*, which is 7 October 3760 in the Julian proleptic calendar (ie the Julian calendar extended backward). Years have 12 or 13 months of 29 or 30 days. There is an intercalary month in each of the Metonic cycle years 3, 6, 8, 11, 14, 17 and 19. The rules are too complex to be described in full in this summary.

The days are reckoned from sunset to sunset. The days of the week have numbers, not names, except for the seventh day, which is *Sabbath* (sunset Friday to sunset Saturday).

The French Revolutionary Calendar

In November 1793, the French Republic introduced a new calendar, which was supposedly based on philosophical and scientific principles. New Year's Day was fixed as 22 September, which was not only the Autumnal Equinox, but was also the day after the establishment of the Republic.

The year had 12 months of 30 days, with five 5 days (6 in leap years) added at the end of the year. The names of the months were taken from nature, with names like fog, rain, seed, and harvest:-

Autumn: Vendémaire, Brumaire, Frimaire
Winter: Nivôse, Pluviôse, Ventôse
Spring: Germinal, Floréal, Prairial
Summer: Messidor, Thermidor, Fructidor.

The calendar came in for a certain amount of ridicule in the enemy country, England, and a parody interpreted the month names as:

Autumn: wheezy, sneezy, freezy
Winter: slippy, drippy, nippy
Spring: showery, flowery, bowery
Summer: hoppy, croppy, poppy!

The calendar was used until 31 December 1805, when Napolean reinstated the Gregorian Calendar. Undoubtedly, one of the reasons for the lack of success of the French calendar was the fact that the week was extended from 7 to 10 days, with just one day's rest every 10 days instead of every 7.

The Indian Calendar

India uses many varieties of calendar. The Gregorian Calendar is used for administrative purposes, but the National Calendar is a luni-solar calendar, reformed in 1957. (Previously there were about 30 calendars in use in India.) It has leap years just like those of the Gregorian Calendar, but the epoch is the *Saka Era*, corresponding to the vernal equinox, AD 79. The months, which are named after the traditional Indian months, are offset from the beginning of the Gregorian months.

The official Indian Religious Calendar (by which holidays are determined) is a luni-solar calendar based on calculations of the actual positions of the Sun and Moon. There are *solar months* and *lunar months*. The solar month is defined as the time for the Sun's apparent longitude to increase by 30° (ie one zodiacal sign). Because of the ellipticity of the Earth's orbit the solar months vary from 29.2 to 31.2 days.

Lunar months are from New Moon to New Moon, with some years having 13 lunar months. The lunar month has the same ➠

name as the solar month in which it starts, but sometimes a solar month will not have any New Moon, so its name is skipped.

To complicate matters even further, there are many local variations, with local calendar makers using traditional astronomical ideas, and producing calendars which are not compatible with the official ones!

In India the question: What's date is it? could have several answers.

The Mayan Calendar

The ancient Mayan calendar was even more complicated. It apparently had 365 days, 18 months to a year, 20 days to each month, plus one short month (*Uyeb*) of 5 days. These five days were very unlucky, and almost every activity had to be avoided during them. They were used in the "*long count*", which was, therefore, based on a 365-day year (possibly with festivals adjusted from time to time to keep to seasons), but they were omitted in the "*short count*", which was used for calculations involving longer periods of time.

The Mayans apparently had names for periods up to 460,800 million days!

The epoch was possibly 10 August 3113 BC. 13 *bakhtuns* (13 periods of 144,000 days, or 394.5 years), was calculated to end with the end of the world on 24 December 2011!

The Mayans used two parallel calendars, one of 260 days and one of 360 days (plus the 5 unlucky days). An inner circle of 260 days (= 20 day-names x 13 day-numbers) was combined with an outer circle to give a dual calendar wheel of 18,980 days (= 52 years). By using such means they could calculate solar and lunar cycles accurately.

The appearance of Venus was considered very important, and was accompanied by religious festivals with human sacrifices. Astronomers predicting these dates needed to be exact, as the usual penalty for getting it wrong was execution!

The Mayan calendar system has never been completely understood. As might be expected these uncertainties have led some people to infer various mystical inferences to it, as can be seen by examination of the Internet, where some people and organisations appear to be seeking like-minded individuals, and even to make money out of it.

The Chinese Calendar

In present-day China the Gregorian Calendar is used for administrative purposes, but the Chinese Calendar is used for traditional festivals and agricultural activities. It is a luni-solar calendar based on calculations of the positions of the Sun and Moon. There is no epoch, the names of the years following a 60-year cycle.

The year names are a combination of 10 "Celestial Stems" (which are Chinese characters) and 12 "Terrestrial Branches", named after animals. Thus we are currently in the year *ding-chou* (*ding* being a Chinese character, and *chou* meaning ox).

The designation of BC years

The use of BC years causes a problem for astronomers. In the 8th century AD Bede counted the years backward from AD 1, preceding the year AD 1 by the year 1 BC. Thus, there is no year zero. This numerical discontinuity must be taken into account when considering astronomical events in ancient times. Astronomers therefore use +1 to designate AD 1, preceded by year 0, which is preceded by year -1. Thus, for example, 46 BC is year -45. ➠

Julian Day numbers

In the 16th century BC, Scaliger tried to create a single system for designating years, by seeking an initial epoch which preceded any historical records. He used three cycles (see box).

Cycles used for Julian Day Numbers

Solar cycle	S	Period after which the weekdays and calendar dates repeat in the Julian Calendar (= 28 years).
Golden Numbers	G	Period after which the Moon phases repeat (approximately) on the same calendar dates (= 19 years).
Indiction cycle	I	Roman tax cycle (= 15 years).

Therefore, a particular year could be designated as a combination of the numbers represented by these cycles: S x G x I. The cycle repeats after 7980 years (= 28 x 19 x 15), and this is the *Julian Year*. The epoch of his system was the year given by 1 x 1 x 1, which is year BC 4713 (= -4712), and Greenwich noon on 1 January of that year is the starting point for *Julian Day Numbers* used by astronomers. The Julian Day starts at noon, so midnight of that day is 0.5 less than the Julian Date at noon. Parts of a day are denoted by decimals.

The Julian Day Number is widely used by astronomers, and for converting from one calendar system to another. It is also easy to determine the day of the week, knowing the Julian Day Number (see box).

To calculate the day of the week

For the Gregorian Calendar:-

$$I = JD - 7 \times ((JD + 1)/7) + 2$$

where JD is the Julian Day Number and I is a number denoting the day of the week (Sunday = 1). Ignore remainders.

For example:-

For 20 May 1997, $JD = 2450589$, so $I = 3$ and the day is Tuesday.

Calendar reform

The Gregorian calendar has a number of problems. The months, quarters, and half-years are all unequal (this particularly affects economic matters such as statistics, salaries, interest, insurance, pensions, prices, and rents). And the days of the week are different for different months and different years.

A number of changes have therefore been advocated over the years, the most popular being the *Universal* or *World Calendar*.

This would have 12 months, with the same names as now. Each quarter would contain 91 days, with the first month having 31 days, and months 2 and 3 each having 30 days. Weeks would continue to consist of 7 days. Since 91 is exactly divisible by 7, the cycle of days of the week would repeat every quarter, with the first day of each quarter being a Sunday. Each quarter would have exactly 13 weeks. ➠

The four quarters of 91 days gives a total of 364 days. Therefore, an extra day ("*Year's End Day*") would be added at the end of December (31 December). There would be leap years, as in the Gregorian Calendar, but with the extra day added at the end of June, rather than the end of February. These intercalary days would not be included in the cycle of days of the week.

One small change, however, could improve still further the accuracy of the Gregorian calendar. John Herschel advocated missing a leap year every 4000 years, to give an average year of 365.24225, ie, only one day out in 100,000 years. It seems to me that this would be a sensible refinement of the calendar. (See box.) ✰

David Le Conte

Accuracy of various calendar years compared with the tropical year

The tropical year is:	365.24220 days	
	Calendar year	*One day out in*
Start with a year of:	365.00000 days	4 years
Add one day per 4 years (Julian calendar):	365.25000 days	128 years
Lose one day per 100 years:	365.24000 days	455 years
And add one day per 400 years (Gregorian calendar):	365.24250 days	3333 years
Lose one day per 4000 years (Herchel's modification):	365.24225 days	20000 years

The World Calendar was last considered by the United Nations in 1955, when agreement could not be reached. Although there continues to be a movement advocating the World Calendar, and other calendar reforms, there has been very little recent interest by governments, religious authorities, or the general public.

Therefore, it seems unlikely that the calendar will undergo any changes in the foreseeable future. If the World Calendar was adopted, the change could most conveniently take place in a year which begins on a Sunday (eg 2006).

However, modern technology creates more difficulties than benefits when dealing with such matters. Organisations currently have a huge problem coping with such a relatively simple matter as ensuring that computer software will work after the year 1999. Based on that experience it would appear that the problems of changing to a new calendar would be insuperable!

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➠

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Millenium footnote

As a footnote to the article on calendars, I was interested in a report on the Royal Astronomical Society meeting of the 10th January 1997, which appeared in the August 1997 issue of *The Observatory*.

Dr Robin Catchpole (Royal Greenwich Observatory) confirmed that the current millenium will elapse at the end of the year 2000, not 1999. He explained that the confusion arises because the year 1 BC was followed by 1 AD, there being no year zero, in the system devised by the 6th century Scythian monk and astronomer Dionysius Exiguus.

Dr Catchpole then addressed the question of where one would have to be in the world to be the first to observe the dawn of the new millenium. He concluded that Caroline Island in Kiribati is the place to head for. He further pointed out that someone really keen could have the novel experience of seeing the new millenium sunrise at Caroline Island, and then dash 1500 miles to Western Samoa to see the last sunset of the old millenium 14 hours 14 minutes later!

The point was made that if we used the binary system, in 2048 we could celebrate the year 100000000000.

A further point was that the date of the millenium really depended on the date of the birth of Jesus, and that it could, therefore, have already happened.

All this goes to show how arbitrary such things are, and how meaningless is the concept of millenium. It depends not only on whatever calendar system one uses, but also the epoch and system of units.

Why don't we start celebrating now! ☆

DLC

Visit the United States Naval Observatory, Washington DC. Story starts on the next page.

A visit to . . . the US Naval Observatory by David Le Conte

As I approached the gates of the US Naval Obsevatory in Washington DC, I was surprised to see them closed and a crowd of people standing inside. I had been advised that the gates opened at 8.00 pm for the regular Monday night tour, which was due to start at 8.30 pm. I had therefore made sure that I arrived well on time, at 8.00 pm. Security is high at the Observatory (not least because the Vice-President of the United States lives on the premises, in the former Observatory Superintendent's house). The policeman at the gate refused any further people entry (there were about a dozen of us), saying that their quota of 90 was full. However, after some deliberation by radio, he did let us in, so I entered the Observatory where, nearly 30 years ago I used to visit officially to check clocks for the Smithsonian Astrophysical Observatory.

The US Naval Observatory (USNO) is renowned as the time-keeper of the United States, and now, in effect, of the world. It is also the home of the US side of the Astronomical Almanac, which it prepares annually in conjunction with Her Majesty's Nautical Almanac Office at the Royal Greenwich Observatory. The Almanac has been published since 1865.

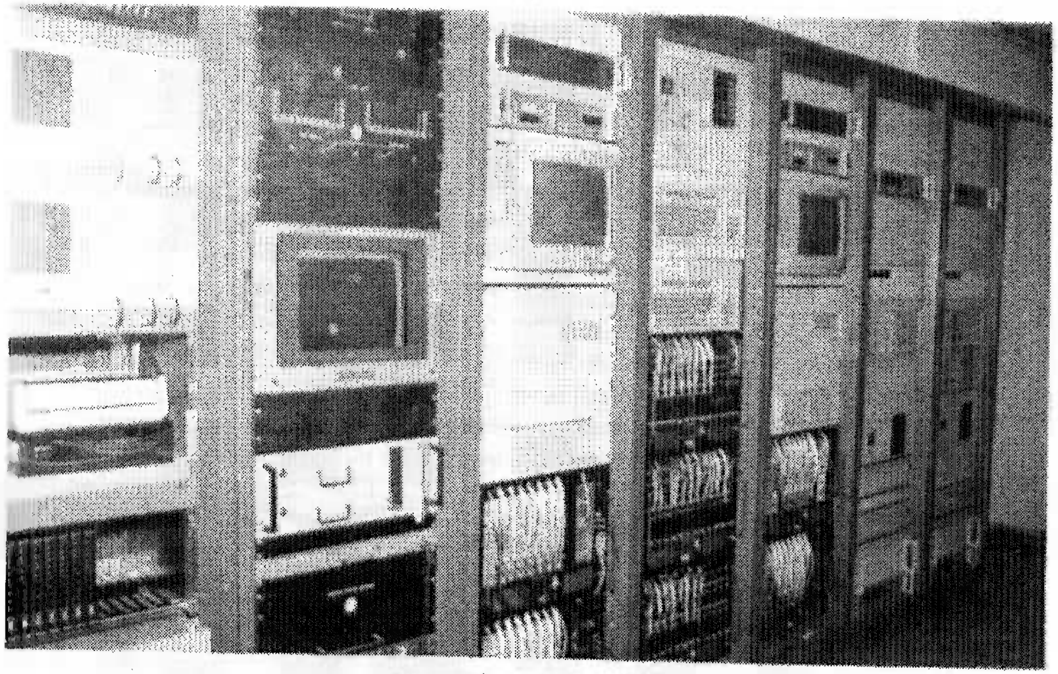
We were first led to the main building (passing the "Stargazer Café" canteen). In the entrance hall I was interested to see a beautiful Alvan Clark 5-inch brass refracting telescope, which had been specially built for the USNO to observe the last transits of Venus – 1874 in Vladivostok, and 1882 in San Antonio, Texas.

We were divided into three groups, and my group was first shown a video about the Observatory. It was founded in 1830, initially as the depot for marine charts, and soon became responsible for keeping time, which, of course, is essential for navigation purposes. The Observatory's early work included cataloguing stars, and observing minor planets and comets.

A curious anecdote mentioned on the video was that in 1863 astronomer Asaph Hall was working alone in the middle of the night, when there was a knock on the door, and President Abraham Lincoln entered, having walked to the Observatory from the White House. He apparently stayed for about two hours, looking through the telescope. This story is even more curious when one remembers that it happened in the middle of the Civil War!

The Observatory's largest telescope on this site is a 26-inch refractor – the same one which Asaph Hall used in 1877 to discover the moons of Mars: Phobos and Deimos. The main telescopes are now located at Flagstaff, Arizona, and include a 61-inch astrometric reflector and a 40-inch reflector. It was with one of these that Jim Christie discovered Pluto's moon, Charon, in 1977.

We then visited the time building, which houses the master clocks. Some three dozen Hewlett-Packard Cæsium clocks, and about ten Hydrogen Masers, are used and inter-compared to produce the world's standard time. The Cæsium atomic clocks date from the 1950s, and are used because the SI (*Système Internationale*) second is defined as the duration of ➡



The United States Master Clock

9,192,631,770 cycles of radiation corresponding to the transition between two hyperfine levels of the ground state of Cæsium 133. So a Cæsium clock automatically provides a standard second. The Hydrogen masers are stable over short time periods, of the order of a week.

The various clocks are contained in humidity- and temperature-controlled chambers, but it is possible to view the Master Clock equipment and display through windows. The intercomparisons are done every 100 seconds, and the clock rate changes by less than 100 picoseconds (100 millionths of a millionth of a second) per day.

The USNO monitors the clocks on some two dozen GPS (*Global Positioning System*) satellites, checking them against its Master Clock. this is important for global navigation systems, which depend on precise time intercomparisons for their accuracy. For example, the USNO points out that an error of just one second would make an aircraft's position inaccurate by one-fifth of a mile.

An integral part of this work is the monitoring of the Earth's rotation, which is referred against the positions of distant quasars. Radio observations using Very Long Baseline Interferometry has replaced optical observations with the zenith tube. This monitoring results in adjustments to UTC (*Coordinated Universal Time*) to keep it within 0.9 seconds of UT1 (the time based on the Earth's rotation, which is non-uniform because of tidal braking action). These adjustments are made by *leap seconds* applied to UTC on a 31 December or a 30 June. The last leap second was made on the 30th June 1997, and the next is likely to be June or December 1998. ➡

USNO time is distributed by radio and telephone. It is also available by computer by dialling 001 (202) 762-1594. More details can be found on the USNO's excellent web site at:

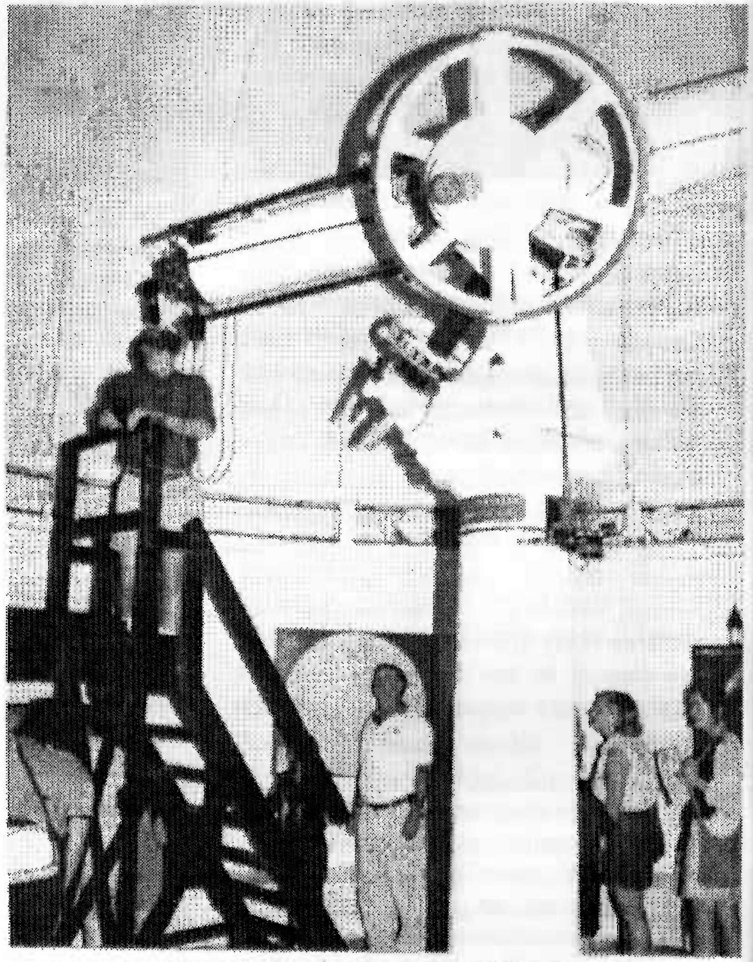
http://www.usno.navy.mil/

Following the visit to the time building, we then visited the Observatory's 12-inch refractor. This historic instrument is over 100 years old. It was used until 1971, when it was dismantled and stored in conditions which resulted in deterioration. It was restored in 1980 by two astronomers at the Observatory.

It is now normally used for staff observing and public viewing. In charge of the telescope this evening was a summer student. Because of cloud she focussed the telescope on lights at the top of the nearby Washington Cathedral, so that visitors could see something!

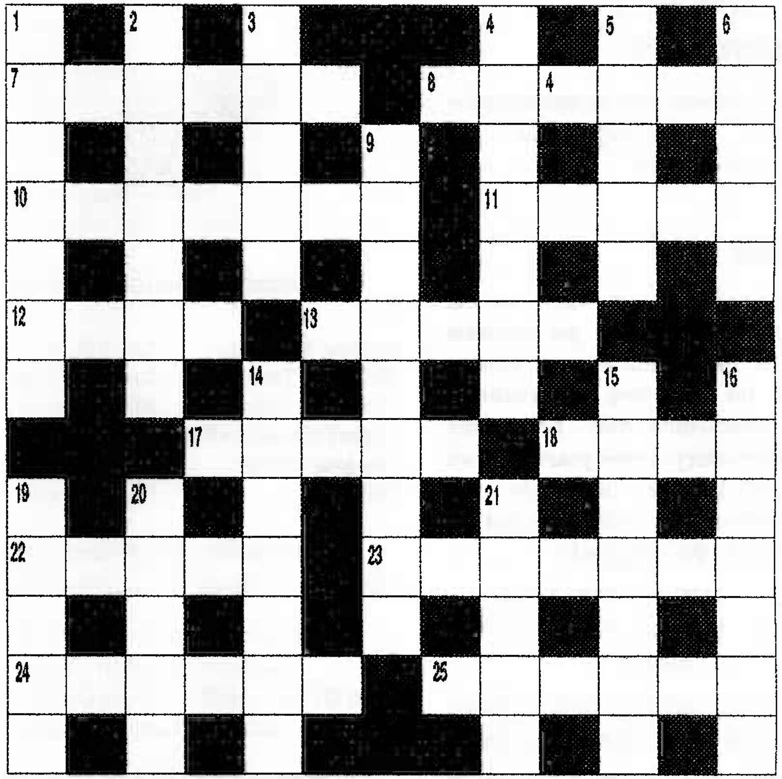
My visit to the US Naval Observatory was most interesting, not least because of its importance in celestial mechanics, astrometry and time, and its continuous history in these fields. For me it was also a return to my past, as 30 years ago I used to enter those temperature-controlled vaults with portable clocks in order to check the Smithsonian Astrophysical Observatory's Master Clock (for which I was responsible) against the United States time standard. I found little had changed, and I was reminded of the time when, after long and careful checking I brought the USNO's attention to the fact that its Master Clock was a millisecond or so wrong! They had to agree with my findings, and made the necessary correction.

More information on the USNO is available at the Section's Observatory. ☆



Observing with the 12-inch refractor at the US Naval Observatory

Astronomical crossword – by "*Mercury*"



The solution will appear in next issue

Across

7 Seventh planet
8 Constellation with second brightest star
10 November meteor shower
11 ______ Newton
12 Race that gave names of most stars
13 Star in Summer Triangle
17 Constellation, would think had high IQ, but actually very dim
18 Volcano on Io; footballer
22 Nebula in Sagittarius; Greek letter
23 Mons ______, on Mars
24 Dog star
25 Country of 16 down

Down

1 Reactions that provide Sun's energy
2 Californian observatory
3 Dilates to let in light
4 Discoverer of Jupiter's moons
5 Double star in Ursa Major
6 Month of vernal equinox
9 Right ______, measure of star's position
14 Constellation with Square
15 Constellation in two parts
16 Cataloguer of fuzzy objects
19 ______ head Nebula
20 Latin name for Earth
21 Largest constellation ☆