Advertisements

Do you have anything for sale, or do you want anything (preferably, but not necessarily astronomical)? Advertise here - no charge.

Fooled you

Anyone tuning into Radio Guernsey on 3rd October expecting to hear your Editor, as mentioned in the last issue of Sagittarius will have heard someone else instead. My spot was the next day. I know at least one person was listening - a recent arrival on the Island, who came along to the Observatory that evening.

DLC

You can help . . .

We have been asked to assist the States Engineers in determining True North accurately for the Liberation Monument, by celestial methods. We plan to do this on a clear night during the next few weeks on a site at the Harbour. If you would like to be involved in this exciting project please let me know.

. . . newsletter too

Articles, snippets of information, book reviews, accounts of visits to places of astronomical interest, and any news of your observing and other astronomical activities are needed for next year's issues of Sagittarius. It's not difficult - give it a try and see yourself in print!

DLC

Astronomy Section Officers

Section Secretary:	Geoff Falla	724101
Honorary Treasurer:	Peter Langford	720649
Light Pollution Officer:	Ken Staples	54759

The next newsletter will be published early in January. The deadline for publication materials is 15th December.

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Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

November/December 1994

Forthcoming events

Orion - the Hunter
by Stephen Jefferys
Tuesday, 15th November
8.00 pm at the Observatory

Quiz and Supper Evening
Quiz-master: Geoff Falla
Tuesday, 13th December
7.30 pm at the Observatory

Plus
regular meetings every Tuesday night from 7.30 pm,
and
observing meetings every Friday night after dark.

In this issue:

the second part of the two-part series on
The Sun, by Lawrence Guilbert
and the start of a new series:
The Liberation Monument
by David Le Conte

Inside

Major articles in **bold**

Centre inserts

Southern winter objects
November/December star chart

Orion - the Hunter

At 8.00 pm on Tuesday, the 15th November at the Observatory, Stephen Jefferys will give a talk about **Orion**. His talk, which will be illustrated with colour slides, will concentrate particularly on the life-cycle of stars, as exemplified by Orion's magnificent variety. He will cover star formation and stellar birthplaces, such as the Orion Nebula, the different kinds of stars, such as Betelgeuse and Rigel, and will describe how the famous Hertsprung-Russell Diagram helps us to an understanding of why stars appear the way they do, in terms of their evolution. He may also touch on the mythology associated with this, one of the best constellations in the sky.

Quiz and Supper Evening

The annual Quiz and Supper Evening will be held **at 7.30 pm on Tuesday, the 13th December, at the Observatory**. Please note the start time, which is earlier than usual. This year, Geoff Falla will be the Quiz-master.

The evening will take its usual format - a pot-luck supper and a wide variety of quiz questions. Please bring a dish, preferably one suitable for eating with the fingers, as we will probably eat during the quiz. Also bring something to drink, As usual, the evening will have a Christmas flavour.

Remember that the quiz is not a test, but a means of learning. Every year we all learn something new. Some questions will be easy, whilst others will no doubt be questions to which no one can be expected to know the answers.

Above all, it is a fun evening, so come along and give it a try. ¤

Your favourite objects

On the 13th September several members spoke about their favourite astronomical objects.

Roger Chandler chose *Saturn*, which is currently well-placed for observing. On the 27th August, no less than six of its moons were seen with the Observatory's telescopes. Roger showed photographs which he had taken of the planet, which clearly showed the rings and the bands on the planet's surface. Saturn always gives a thrill, especially for people who have never before seen it through a telescope. So take the chance now, while it is well placed. And don't forget that its rings are closing up and will become invisible late next year for a few months.

Daniel Cave's selection was the *Swan Nebula* in Sagittarius, which is best visible in early July. Lying near to the Eagle Nebula the Swan also goes by the name of the Omega Nebula, the Horseshoe Nebula, M17 or NGC6618. The Swan Nebula was discovered in 1664. Its size is 7 by 2 arc-minutes, and it looks just like it does in photographs, having a distinctive swan-like shape. The Nebula is crossed by a dark dust cloud, and infrared photographs show more stars inside it. It is also a strong source of radio emission.

Daniel showed photographs which he had taken with the 8-inch Schmidt camera and with the 14-inch Celestron. He explained that the Swan Nebula is 12 light-years long and 5700 light-years away. Its outer portions have been traced to 40 light-years. It has a total mass 800 times that of the Sun, and 30 stars are associated with it.

The Swan is certainly a beautiful object to look at, so next July ask Daniel to show it to you. »»

David Le Conte's choice was the Ring Nebula, M57, in Lyra. At a declination of +33% it reaches a high altitude (virtually overhead), and is therefore easy to observe. It also has the quality of being able to take high power, whereas some nebulous objects are best seen only at low powers.

The Ring Nebula is one of the class of so-called *planetary nebulae*, which actually have nothing to do with planets. David showed pictures of several such objects. They are the remains of stars which have "died". They were given the description "planetary nebulae" by William Herschel because they looked rather like the planet Uranus, having a greenish tinge. Indeed, the green colour was once thought to be caused by a new element, and it was given the name "nebulium". It was later found to be due to "forbidden" lines of ionised oxygen.

David said he had never seen the central white dwarf star, which is 14th magnitude. Planetary nebulae exist in this form for only about 50,000 years, and this explains why there are comparatively few of them. The "Dumbbell Nebula" is one of the best known examples.

While many sources quote distances and angular diameters, it is not easy to find out the actual sizes of such objects. David had therefore calculated that, at a distance of 2,000 light-years, and an angular diameter of 71 arc-seconds, the Ring Nebula must have a diameter of 4 million million miles, or 2,000 times the diameter of the solar system.

Debbie Quertier spoke about the area around **Orion**. She described the giant red star, Betelgeuse, some 250 million miles in diameter, contrasted with blue Rigel. She also enthused about the distinct shapes of nearby bright constellations, such as Taurus and Gemini, and spoke of the Hyades star cluster, Cancer and the bright star Procyon.

Debbie's description of Orion and its neighbours led to a general discussion on the Orion and Horsehead Nebulae.

Antony Saunders chose the **Big Bang** as his favourite object, and he asked questions such as: "What was before the Big Bang?" "Was there any "before"?" "Is the universe recycling itself?" "Why is there more matter than antimatter?" "Is the universe oscillating?" "Will there be an end?"

It has to be admitted that there were few, if any, answers to these deep questions, and a lively discussion rounded off a very pleasant evening.

Video evening and star night

About 20 members of the public turned up for the Video Evening at the Houguette School on the 11th October, with a sprinkling of Section members. Extracts of three videos were shown by Geoff Falla: The Universe (the solar system and galaxies), Saturn and its moons, and the Dream is Alive (about the Space Shuttle). This was followed by computer images of the comet Shoemaker-Levy 9 collision with Jupiter last July, shown and described by David Le Conte.

We then all went up to the Observatory, and enjoyed a clear, warm, but dewy night. Good views of the first-quarter Moon and Saturn were obtained, and a few other objects (M15, M31 and M57) were also seen with the 14-inch and 11-inch telescopes. »»

Although the turn-out was poorer than hoped for, those people who came all seemed really interested and welcomed the opportunity. A few donations were received for Section funds.

Many thanks to those members who assisted with this event: Roger, Bert, Debbie, Lawrence, Geoff and David. Suggestions about the organisation and publicity for future similar events would be welcomed. This time, unlike last year when at least three times as many people came, we did not circulate the schools, and this could well account for the fewer numbers, as there were few children.

We are still without an Education Officer, and anyone willing to take this on would be very welcome to do so. The duties are not onorous. A Publicity Officer would also be a good idea. ¤

Women's Institute visit

A dozen members of the Mare de Carteret Women's Institute enjoyed a visit the Observatory on Monday, the 26th September, and were able to see a few objects, including Saturn.

. . . hear talk . . .

David Le Conte gave a talk to the St Saviour's Women's Institute on the 12th October on the subject of his work with NASA in the 1960s.

The WI has donated the sum of £35 to the Section because of the recent talks and visit. ¤

. . . Brownies too

On the 7th November, probably after you have received this newsletter, the St Martin's Brownies will be visiting us.

CCD acquired

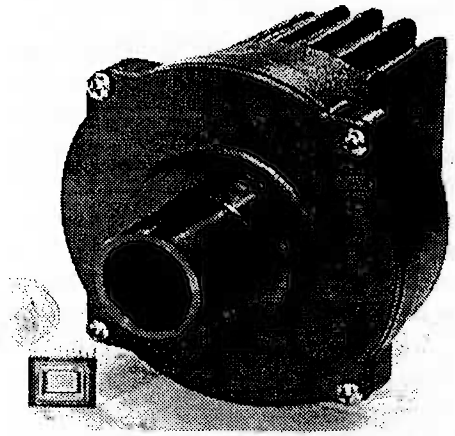
Members will be aware that an ambition of the Section for the past year or so has been the acquisition of a Charge Coupled Device (CCD) imaging system. After some deliberation and careful analysis, by Daniel Cave and Jim Cheetham, of the various CCDs on the market, the Starlight Xpress 'SX' astronomical imaging system was chosen.

Daniel is well acquainted with CCDs, having worked with them at university, and followed their development with interest. Jim is a computer professional, and therefore well placed to evaluate the computer needs of the system. Having decided that the Starlight Xpress was the system for us, we checked with other CCD users for reassurance that it was satisfactory.

The particular choice was the 500 x 256 pixel mono camera head, which should give good resolution. It cost just under £600. We decided on the system excluding the frame store module (which costs about £800 extra), so that the images are downloaded straight into a computer. The system is upgradeable should we decide at a later date that the frame store is desirable. Filters can be added to take three images in different colours, which can be combined to give colour pictures.

At the present time, the Section does not possess a suitable computer, although, of course, several members have their own computers, including portable machines. However, it would be most desirable for a computer to be dedicated for this purpose, and if anyone knows of a possible source of a suitable machine at a reasonable cost, please get in touch with Geoff Falla or myself. »»

What is a CCD?



The Starlight Xpress 'SX' CCD system

A CCD imaging system is a device rather like a video camera, but which makes single images of astronomical objects. Thus it can be used in place of a normal camera to take pictures. It fits on the telescope in place of an eyepiece. Its advantage is that it is very fast. Faint objects can be imaged with relatively short exposures, and images of planets do not suffer from the "seeing" defects suffered by longer exposure photographs.

Furthermore, the image is in a digital format, so it can be processed within a computer, and "enhanced" to bring out details not apparent in the original image.

First light

The Section's CCD was picked up by David Le Conte at the manufacturer's premises in Reading on the 26th October. It was first tried on the 14-inch Celestron on Tuesday the 1st November. About a dozen members were present to see this first trial.

Ideally we would have used the Moon, as a bright, easily focussed object. However, the Moon was close to New, and therefore not visible. We therefore selected Saturn, as a bright, easily recognisable object. We used portable computers provided by Jim Cheetham and Steve Doherty.

Unfortunately, cloud increased substantially during the trial, and Saturn kept disappearing. We also tried some bright stars and terrestrial objects. Considerable difficulty was experienced in focussing under these adverse conditions. An image of Saturn was obtained, but much more work will be needed before focussing becomes a matter of routine.

The opportunity for further trials will be taken when the Moon reappears. Hopefully, it will not be long before we can publish pictures similar to the one of M51, below. ¤

David Le Conte

The Whirlpool galaxy imaged with a Starlight Xpress 'SX' CCD system (320 seconds, F5 Newtonian).

Famous lives - 5 Johannes Kepler (1571 - 1630)

Kepler's early years, in the city of Weil der Stadt, must be regarded as some of the most difficult and inauspicious of all the great astronomers to be discussed in this series. He was born into an unloving, broken family, where his father was often away, fighting as a mercenary, while his mother was an odd mystic-like woman, who, in later life, was to face charges of being a witch!

The man himself was to know an unloving childhood - always a hard life with little money and, on occasions, little food. He was to suffer much ill health, including terrible boils and skin disorders. Finally, complete the list by adding that one of the greatest astronomers of all time was terribly short-sighted, and so never saw the heavens in all their full glory!

His early education took place at the convent schools at Adelberg and Manlbronn, until 1589 when he entered the University of Tübingen. It was during his year at the University that Kepler became familiar with the teachings of Ptolemy, and later introduced to the heretical teachings of Copernicus by one of his mathematics tutors named Michael Maestlin.

It is important to remember that at this time Kepler's training at University was theological, as he was being prepared to enter the Church. All this was to change suddenly in 1594, when the position of mathematics tutor became vacant at the Protestant Seminary of Graz in Austria. Kepler was recommended for the post; he accepted after some delay, and so, at the tender age of 23 he became a professor of mathematics. Eventually, thoughts of a life in the ordained ministry faded, and the world gained one of the greatest theoretical astronomers.

Kepler was to remain at Graz until September 1600, when, due to religious persecution he and his family were exiled along with many other protestants. However, during his six years at Graz he was to establish himself as a leading mathematician and theoretical astronomer, with his studies on the orbits of the planets. His researches were published in his work of 1597, entitled the *Mysterium Cosmographicum* or The Mystery of the Universe. The work changed Kepler's life and brought him to the attention of scientists and scholars across Europe. One in particular, Tycho Brahe, was to play a particularly important role in his future. Of this first book itself, Kepler wrote: "*The direction of my whole life, my studies and works, took its departure from this one booklet.*"

Kepler first met Tycho in the early months of the new century, February 1600, when he visited him at his castle in Prague. At this first meeting Tycho did not offer him the position of Assistant, but Kepler stayed to carry out some work in the hope of a permanent offer being made.

It appears that the two great men did not find working together easy, and many arguments broke out. Tycho denied Kepler vital observations necessary for his work, and, although Kepler was aware of it, Tycho was attempting to secure an Imperial position for Kepler, something he was to achieve just before his death.

Kepler and his family eventually moved to Prague for good after their exile from Graz. By this time peace had broken out between the two men, and Kepler had »»

been assigned to work on the theory of Mars's motion, which eventually was to lead to his formulating his famous planetary laws.

Before these laws were published, much work was necessary and access to Tycho's observations. All was to be revealed to Kepler when, in November 1601, the greatest living astronomer of his day died, and Kepler was appointed his successor by the Bohemian Emperor Rudolf.

Before continuing it is important to reflect upon the importance of the time the two men spent together, brief as it was. Kepler wrote "*If God is concerned with astronomy, then I hope that I shall achieve something in this field, for I see how God let me bound up with Tycho.*" Without the observational data compiled by Tycho, Kepler would never have formulated his planetary laws.

The main stumbling block in Kepler's work was the teaching that the planetary orbits were regular or perfect circles. Although Kepler laboured for five years on his work, it was not until he replaced the perfect circle with an ellipse that his calculations and Tycho's observations tallied, and his first two planetary laws of motion were published in his work *Astronomia Nova* or The New Astronomy in 1609.

His third law was not to follow until 1619 in his work *Harmonice Mundi* or World Harmony. He was also troubled and never fully understood the force that kept the planets in their orbits - the same force that gave them a variable speed. He was, of course, laying the ground for a future astronomer - Newton - to explain more fully. Kepler also published numerous other works, including an introduction to optics, which again Newton was to use to his advantage.

Finally, on November 15, 1630, worn out after years of work, illness, personal grief and unhappiness, Kepler died of a fever while visiting the city of Regensburg. He was 58 years of age. His work was to form the basis of modern day celestial mechanics. He composed his own epitaph:

Once I measured the heavens,

Now I measure the shadows of the earth.

Although my soul came from Heaven,

The shadow of my body lies here. ¤

David Williams

References:

Johannes Kepler, by David C. Knight

The Penguin Dictionary of Astronomy

Pioneers in Astronomy

Kepler and Planetary Motion

While completing background reading for my *Famous Life* article on Kepler, I became fascinated with his work into the formulation of his three laws of planetary motion. I felt that a more thorough description of his work was warranted, and so a further article will follow in a future issue of Sagittarius.

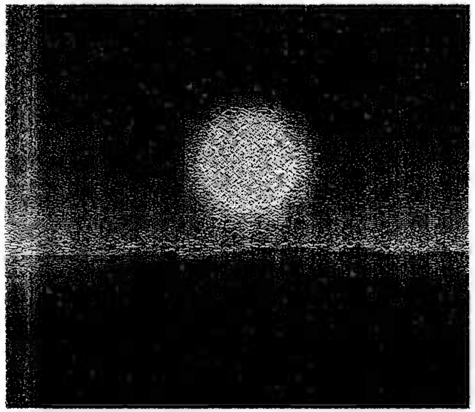
DW

DoE Award successes

Congratulations to two Ladies' College girls, Zoë Byrom and Jane Porter, who have completed a twelve-month course in astronomy for their Gold Duke of Edinburgh Award, under David Le Conte's general guidance, and with the assistance of other Section members.

The Sun - Part 2 *by Lawrence Guilbert*

The second and final part of Lawrence's paper.



The Sun's core

Nobody has ever seen the interior of the sun, nor are they ever likely to. However, scientists believe that at the very centre, and stretching a quarter of the way to the surface, is the core formed by the gravitational condensation of the heavier metallic elements, with a temperature of 15,000,000°C (27,000,000°F) at a density of 12 times that of lead.

It was in 1926 that Sir Arthur Eddington, a brilliant astrophysicist and one of the greatest Englishmen of his time, who proposed that it is atomic or nuclear fusion that provides the energy for stars, and, of course, the Sun to be a perpetually exploding hydrogen bomb.

The radiation zone

The nuclear fusion that occurs is so powerful that every square metre of it emits 70,000 horsepower of energy into space. It has been calculated that a mere pinhead of material from the core would be enough to ignite everything for 60 miles around. These conditions are extreme enough for nuclear fusion to take place, and every second millions of tons of hydrogen are fused into helium and converted into energy which then radiates out from the core into the radiation zone which surrounds the core and extends four-fifths of the way to the surface. The significance of these figures will be better appreciated if one compares them with the fact that water boils at 100°C or 212°F, and also that iron melts at 1485°C, which is 2700°F. To generate energy on this scale the Sun would need to burn about 11 million times the word's annual output of coal every second.

Convective zone

From the radiative zone this energy is driven on into the *convective zone* by the heat from the interior. This zone extends to within 100,000 km of the surface, and consists of layers of cells, each smaller than the one below. The outermost cells are about 60 miles across, and each cell is bordered by an area in which gas sinks back into the Sun.

Photosphere

The next region is the *photosphere*, and this constitutes the "apparent surface" of the sun. I say "apparent" because there is no real surface. Here the temperature is reckoned to be 6,000°C. The photosphere often shows a mottled or granular appearance as a result of our viewing the tops of the convection cells - bright where the hot gases are rising from the centre of each cell, and then they cool and sink back along the boundary of each cell. This is only seen when the image of the Sun is projected and the "seeing" or state of the Earth's atmosphere is steady. »»

The photosphere is reckoned to be about 290 miles thick, and above that lies the *chromosphere* (literally, colour sphere), which is a layer of hydrogen gas only a few thousand miles deep. Its temperature rises from about 4,000°C to around 50,000°°C, with increasing altitude. It seems to be highly illogical that this layer should have a temperature far higher than the surface, and scientists have not as yet fathomed this out. The chromosphere is usually only seen at the time of an eclipse, when the Moon's disk covers the Sun, allowing the chromosphere to appear as a ring of pink light surrounding the limb of the Sun.

Bernard Lyot

Outside the chromosphere there is a vast envelope of tenuous or rarefied material called the *corona*, which is the outermost region of the Sun's atmosphere. This too can only be seen at the time of an eclipse, when it appears for a few minutes, and exhibits a delicate white radiating structure. Near sunspot minimum the corona possesses long fan-shaped streamers stretching radially outwards, whilst at maxima the outline becomes irregular.

Professional astronomers can now observe the corona at other times by using special techniques, an instrument called a *coronograph* devised by Bernard Lyot, a leading French astronomer in 1930 at the Meudon Observatory near Paris. For this and other notable contributions to the study of the sun, Moon and planets, he was awarded the Gold Medal of the Royal Astronomical Society in 1939.

The solar wind

The size and shape of the corona varies in relation to the level of sunspot activity. In places, particularly above the sun's magnetic poles, gaps appear in the corona, and the light glows less intensely. These *coronal holes* are the sources of the *solar wind*, a great stream of atomic particles that have escaped the Sun's magnetic grip and slipped out into space. These charged particles or ionised gas are intensely magnetic, and they move in every direction, sometimes being referred to as corpuscular radiation, but more often known as the solar wind. These atomic particles are sprayed out almost like water from a hose. They approach the Earth at a speed reckoned to be around 400 km per second, and are deflected around the magnetic field to the magnetic poles.

Aurorae

On entering the ionosphere these particles cause a gaseous discharge which produces the glow which has become known as the *Northern Lights*. They are observed mainly in sub-polar regions, but can, however, be seen in our latitude when displays are particularly brilliant. The effect is rather like the dawn glow, and it was termed by Gassendi in 1621 as the *Aurora Borealis*. A hundred and fifty years later Captain Cook saw this same display in the sky whilst voyaging in the Southern Hemisphere, and named it the *Aurora Australis*.

These displays are truly wonderful sights, and can be very beautiful indeed, the sky glowing with coloured lights. It is usual for red and green to predominate, sometimes in great areas or patches, and others in streamers, much like searchlights. Flickering and rippling can take place, whilst at times they resemble curtains or draperies hanging in folds, shimmering and dancing. They often go on changing shape for hour after hour. »»

Ancient peoples were terrified and awe-struck by the flaming pulsating brilliant red and green glows. Aristotle wrote about them as long ago as the fourth century BC. In the Middle Ages aurorae were often described as fiery dragons, burning spears, beams of fire, or divine revelations. Superstitious folk even predicted that they denoted the end of the world.

Observing sunspots

Modern sunspot observations gathered interest around 1912, when George Ellery Hale began operating the famous 150-foot Solar Tower telescope at Mount Wilson in California. It was Hale's photographs that revealed the sunspots to be huge hurricane-like vortices.

Amateurs, when working seriously, project the Sun's disk to an image size of 6 inches to facilitate comparison of results amongst themselves. The sunspots appear on these images as dark blobs or almost black spots. Careful examination of these will reveal quite a lot of information. Sunspots do appear singly, but most often in pairs, although it is often difficult to make out the comparison, When in pairs they are termed *preceding* and *following*, and are oriented east-west, with opposite magnetic polarities like those of a horseshoe magnet.

Solar flares

At times, intense magnetic fields become entangled, causing a sudden flash of energy, known as a *flare,* that may last from just a few minutes to an hour or more. These flares are the most violent happenings on the Sun, some releasing enough energy that, if it could all reach Earth, would melt all the ice at both the north and south poles, to say nothing about the havoc it would bring to communications.

Sometimes a large flare can be seen in white light; in fact the earliest record is probably that of Richard Carrington, the English amateur in 1859. Flares are usually associated with large, newly formed sunspots, and are believed to originate in the atmosphere. They are sometimes termed *atmospheric eruptions*, and are contributors to the *solar wind.*

The dynamics of sunspots

Large sunspots or groups can be very active, and can show striking changes in just a few hours. The centre of a large spot can usually be seen as an area far darker than the remainder. This is known as the *umbra*, and the surrounding part, of a much lighter tone, the *penumbra.*

Really big sunspots may contain two or more *umbrae* within the penumbra. They frequently have a retinue of smaller ones, scattered around. Other groups may have two prominent spots, one larger than the other, and a number of much smaller spots travelling along behind. On some occasions the penumbrae of the larger spots expand and become one, sometimes enveloping some of the smaller spots until reaching maximum in about ten days. Then the lesser spots gradually disappear, followed by the second of the two main ones which breaks up before finally disappearing. The main spot starts to shrink and finally fades away, but does not beak up as did its former "companion".

The life of sunspots varies greatly, whilst some small spots, particularly the very small ones - astronomers call them *pores* - are apparent for only a couple of hours. Others have been known to survive for almost six weeks. Such spots are termed as *quiescent.* »»

Solar rotation

Providing it lives long enough, a spot can be seen to travel right across the Sun's disk, disappear over the limb, and then, almost two weeks later, to reappear at the opposite edge. As mentioned earlier, it can be stated that the Sun revolves on its axis in something approaching a month. Actually, this is a little inaccurate, because during this time the Earth has been moving on its orbit around the Sun, as viewed from Earth.

Because of the Sun's gaseous nature and the difference in revolutionary time at different latitudes, spots nearest to the equator move round more quickly than those in higher regions.

A record sunspot group

Small spots, or pores, are only a few hundred miles in diameter. Some are possibly smaller, whilst the larger ones can be tens of thousands of miles across. Groups can extend to 100,000 miles.

In 1947 a particularly spectacular peak was reached, and a single grouping of sunspots appeared covering about 6,000,000,000 square miles of the Suns surface. It was the largest group ever recorded, easily visible with the unaided eye. It survived for several rotations before finally dying out.

Sunspot activity occurs mainly in the areas from 5° north or south of the Sun's equator, up to 40°. Very seldom do they appear outside of these limits. However, in 1956, during a maximum period, a group did appear at an unprecedented latitude of 50°.

And finally -

Summing up, the Sun today is a very ordinary star - a yellow dwarf of spectral type G2V on the main sequence. It began its life some 5 billion years ago when the Solar System was born. It lies just about half-way between the largest and smallest, between the hottest blue and the coolest red stars. As viewed from Earth, it is a hundred billion times brighter than any other star, though Rigel, for example, at the same distance would be 15,000 times more luminous, and 36 million Suns could be fitted into Antares, a red super-giant.

In about another 5 billion years the Sun will have used up all its hydrogen. The tremendous heat at its core will move outwards, forcing the Sun to expand, and it will become a giant red star, like Antares. It will blow up to a monstrous sphere of extremely rarefied, red-hot gas, large enough to engulf Mercury, Venus, Earth and Mars.

Finally, the Sun will cool and shrink, ultimately becoming a white dwarf no bigger than the Earth, but weighing several tons to the cubic inch. However, today we stand at the threshold of exciting new knowledge, as rockets and satellites probe ever deeper and deeper, and coming years could well revolutionise our understanding of these things. ¤

Lawrence Guilbert

Liberation Day event

In the last issue we reported that we were considering setting up telescopes for the public at the Harbour on Liberation Day next year, when the 50th Anniversary of the Liberation will be celebrated. We have now heard that our application has been accepted by the States Liberation Day Committee, and we will therefore be part of the official programme.

The Liberation Monument

Remember the "What's Going On Here?" picture in the last issue of Sagittarius? It showed the experiment conducted at the Observatory to check the design of the proposed Liberation Monument. I was asked by the Monument Working Party to assist by calculating the curve which the tip of the shadow of the 5.25-metre high obelisk will follow throughout the day of the 9th May 1995, the 50th Anniversary of Liberation Day, which the Monument will commemorate. This work was carried out in the name of the Astronomy Section. The tip of the shadow will fall on stone seating which will be marked at appropriate positions with the events of Liberation Day, the 9th May 1945.

Work on this project was carried out during July and August, and the calculations were completed and checked by early September, when the report of the Liberation Day Committee had to be submitted for the consideration of the States. The States approved the Monument by a vote of 38 to 17, and construction is proceeding.

A lot was learned during this project. It was necessary to calculate the path described by the tip of the shadow, with an accuracy approaching one millimetre. The problem is essentially that of a sundial calculation (horizontal sundial with a vertical gnomon), with the difference that:-

- Only one day each year is being considered.
- The length of the shadow, as well as its direction is required.
- A high accuracy is needed.

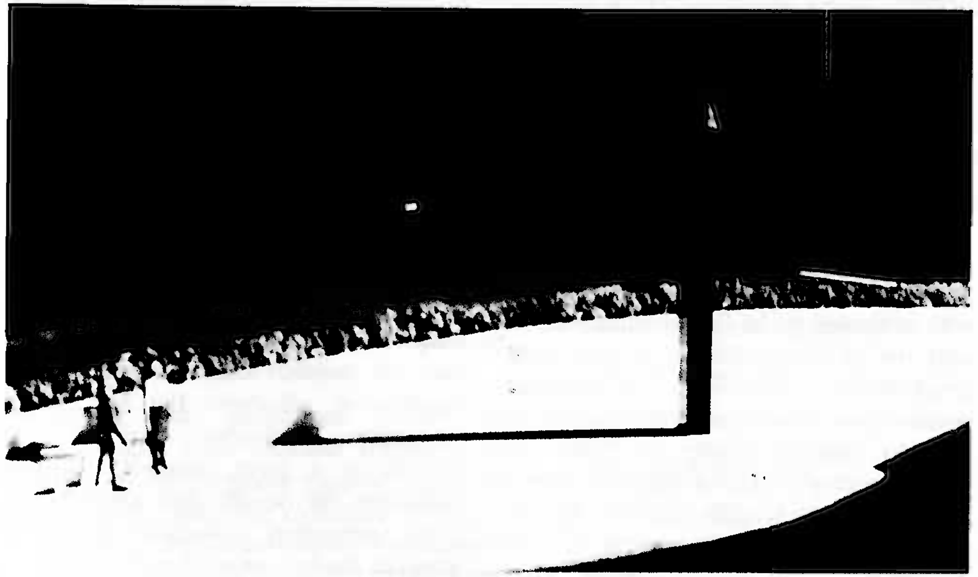
The first task was to calculate the accuracies required.

Accuracy required in shadow direction

At 0600 UT on May 9 at the latitude and longitude of the proposed monument the Sun's altitude is about 12°, and the shadow length of the gnomon (obelisk) is approximately 22 metres. For an accuracy of one millimetre in the length of the shadow, the altitude must be determined with an accuracy of 0.0005 degrees. At 1200 UT the Sun's altitude is 58°, the shadow length is only 3.1 metres, and an accuracy of 0.01 degrees is more than sufficient. While an accuracy of 0.01 degrees in the prediction of the Sun's position is relatively easy to obtain, an accuracy of 0.0005 degrees is not.

However, at 0600 UT the shadow length changes by about 300 millimetres *per minute*, or 1 millimetre in 0.2 seconds. As the monument is not intended to be more precise than, say, a quarter of a minute in time, it is clearly unnecessary to seek a greater accuracy. An error of 0.01 degrees in the Sun's altitude at 0600UT would give a shadow length error of 19 millimetres, corresponding to less than 4 seconds in time.

In addition, the Sun's actual altitude early in the morning (and late in the evening) is affected by atmospheric refraction. The amount of refraction depends upon the atmospheric pressure and temperature, increasing with increasing pressure and decreasing temperature. The author of books and articles on precision astronomical calculations, Jean Meeus, points out that near the horizon the unpredictable disturbances of the atmosphere become important, and that *"giving the rising or setting times of a body more accurately than to the nearest minute makes no sense."* »»



The proposed Liberation Monument

There is a further inherent inaccuracy in the determination of the length of long shadows. When the Sun is at a low altitude, giving a long shadow, the penumbral effect will be dominant. The umbral tip of the shadow will be difficult to determine under these conditions. Thus, practical observation of the precise position of the shadow at this time is likely to be inherently inaccurate.

At 1200 UT the shadow length changes by only a fraction of a millimetre per minute, the Sun's altitude changing very little. So the errors in shadow length are tiny at midday, although, as the shadow length changes slowly, the time errors are considerable.

Accuracy required in shadow direction

At 0600 UT the shadow direction changes by only 0°.18 per minute. For this gnomon (22 metre shadow) this corresponds to a lateral movement of 70 millimetres per minute, or just over one millimetre per second. An error of 0°.01 in the Sun's azimuth would give a lateral direction error of less than 4 millimetres, equivalent to about 3.3 seconds in time. This is well within the required accuracy of the monument.

At 1200 UT the shadow direction changes by 0°.45 per minute. The shadow is 3 metres long, and the lateral movement is 24 millimetres per minute. An error of 0°.01 in solar azimuth results in a lateral error of only half a millimetre (less than 1½ seconds in time).

Accuracy required along shadow path

However, for the purpose of the design of the monument, the important errors to consider are those along the path of the tip of the shadow. Errors along the path are obtained by projecting the shadow direction errors onto the path. They are therefore entirely dependent upon shadow direction errors, not shadow length.

The anticipated errors caused by an error of 0°.01 in the calculation of the position of the Sun were calculated. The average error along the shadow path is about 2.3 seconds.

Site coordinates

The latitude and longitude of the site were measured from the largest scale marine navigation chart published at the Admiralty. The accuracy of the position was estimated to be 0.1 arc-minutes. A trial run of the prediction program with longitude 0'.1 offset from the measured position gave a maximum difference of 3.6 mm in shadow length at 0540 UT (corresponding to about a third of a second in time), and a difference in shadow direction of 0°.001. From 0710 UT the differences in shadow length were fractions of a millimetre. At 1200 UT a 0'.1 offset in longitude gave a difference of 0.006 mm in shadow length, and a difference of 0°.003 in shadow direction.

The height of the site above sea level was taken to be zero, as it is adjacent to the Harbour of St. Peter Port. An error in height of 10 metres would result in an error in Sun position of less than one hundredth of a millionth of a degree.

The prediction program

Initially, the use of commercial software was investigated, especially the program *NightSky* for the Archimedes computer. The accuracy of the program was checked using calculations by Jean Meeus. While the results compared well, the output of the *NightSky* program gives azimuth and altitude to one-tenth of a degree only. Other commercial software is available, including many programs for PC computers, but they are not always well documented, and it is therefore not always clear what factors have been taken into account. In addition, I felt that it would be easier to create a program to provide the specific data required for the project.

I had already written a computer program to predict sunrise, sunset and twilight, which calculated the position of the Sun at those times to an accuracy of one hundredth of a degree. I therefore modified the program to take as inputs any specified intervals of time, and the gnomon height, and to provide the required shadow data as output. The program, called *SunShadow*, calculates the Sun's Right Ascension, declination, azimuth and altitude at a given moment. It then calculates the length and azimuth (i.e. polar projection coordinates) of the gnomon shadow, as well as the east-west distances and north-south distances (i.e. rectangular coordinates) of the tip of the shadow. The latter coordinates were provided to assist in the design layout of the monument.

Checks on the accuracy of *SunShadow*

SunShadow uses Meeus's "low accuracy" (i.e. to 0°.01) method of calculating the solar coordinates, and includes a correction for atmospheric refraction by Bennett's formula. The program was checked against Meeus's calculation of the position of the Sun at a particular time, and the correct values calculated (by Meeus) in accordance with the complete VSOP87 theory.

The total error was 0°.0030. This result is well within the required accuracy of 0°.01, and indicates that the maximum error of the shadow predictions may be better than one second, rather than over two seconds. However, if a prediction accuracy better than one second had been required, then further minor effects, such as the leap seconds occasionally applied to time standards, would have had to be taken into account.

A check was then made against the U.S. Naval Observatory's *1994 Floppy Almanac* (through a computer modem link with the Royal Greenwich Observatory) for two prediction times on 1994 May 09 (the *1995 Floppy Almanac* was not yet available). The total differences were 0°.0054 and 0°.0056 respectively, again well within the required accuracy of 0°.01.

Finally, the predictions given by *SunShadow* were checked against those given by the computer program *Mica*, the Multiyear Interactive Computer Almanac, issued by the Astronomical Applications Department, US Naval Observatory, Washington DC. This program is equivalent to the *Floppy Almanac*, and gives highly accurate positions of celestial objects, as published in *The Astronomical Almanac*. The program does not include altitude corrections for atmospheric refraction, and these corrections therefore had to be added to the altitudes predicted by the program. They were determined from Bennett's formula:-

$$alt = alt + 0.0167 \tan(alt + 8.6 / (alt + 4.4))$$

(where *alt* is the altitude in degrees), and were checked against refraction corrections calculated for similar Sun altitudes by the *Floppy Almanac*.

All the predictions of shadow direction given by *SunShadow* were well within 0°.01 of those given by *Mica*. The predictions of shadow length given by *SunShadow* are within one millimeter of those derived from *Mica* for the period 0800 UT to 1600 UT. The shadow length predictions differ by a maximum of 10.2 mm at 0540 UT, decreasing to 1.5 mm at 0700 UT. These early morning differences are not considered significant, for the reasons already given.

Predictions for 1995

The computer program *SunShadow* gives, for the Sun:-

Right Ascension (in decimal hours)

Declination (in decimal degrees)

Azimuth (in decimal degrees)

Altitude (in decimal degrees)

and for the shadow:-

Length (in millimetres)

Azimuth (in decimal degrees)

East-west distance of tip of shadow from gnomon (in millimetres)

North-south distance of tip of shadow from gnomon (in millimetres).

SunShadow was run for 5 minute intervals for the required period throughout the day.

1995 May 09 was selected as it is the date chosen for the public completion of the Liberation Monument (on the 50th Anniversary of the Liberation). The shadow length and direction will be slightly different on May 09 for other years, as the Sun's apparent position changes slightly with changes in the Earth's position in its orbit, changes in the Earth's orbit, and with the effect of leap years. The predicted positions of the shadow in future years are discussed later in this series.

Comparison with 1945

For interest, *SunShadow* was also run for 15-minute intervals on 1945 May 09, the date of the Liberation. The differences »» at 0615 UT are:-

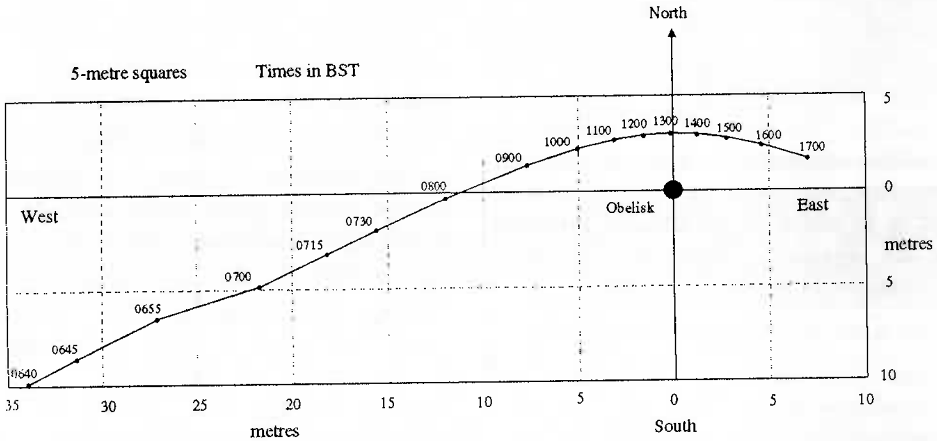
Right Ascension of Sun (hr)	0
Declination of Sun (degrees)	0.03
Azimuth of Sun (degrees)	0
Altitude of Sun (degrees)	0.04
Length of shadow (mm)	50
Azimuth of shadow (degrees)	0
East - West distance (mm)	- 49
North - South distance (mm)	- 8

Plots of the path of the shadow tip

Plots were made of the path of the tip of the shadow, both in polar coordinate and in rectangular coordinate systems. The rectangular coordinate plot is shown below.

about 1.07 pm BST. This is due to three factors. The first is the offset of BST from UT (i.e. Greenwich Mean Time or GMT) by one hour, so that midday falls close to 1.00 pm rather than 12 noon. The second effect is due to the longitude of the site. At approximately 2½° west, Guernsey's local time by the Sun is some 10 minutes later than the Greenwich meridian (since the Earth rotates eastwards at 360° per day, or one degree in 4 minutes).

The third effect is the Equation of Time, which is the difference between the Mean Sun (which gives clock time), and the True Sun (ie the position of the Sun). The Equation of Time varies between minus $14^{m}\ 15^{s}$ and plus $16^{m}\ 25^{s}$ during the year. On May 09 it is $+03^{m}\ 32^{s}$, so that amount of time must be subtracted from the time



Rectangular plot of the path of the tip of the shadow

It will be seen that there is an apparent "kink" in the shadow path at 0700 BST. This occurs where the shadow jumps from the lower level of the paving to the higher level of the seating, a vertical distance of 0.80 metres.

It will also be seen that the shadow does not fall due north at "midday", but rather at shown by a sundial in order to obtain clock time.

Thus, the Sun is due south, and the shadow due north at the clock time given by:-

	$12^{h}\ 00^{m}\ 00^{s}$	*Midday*
+	01 00 00	*BST*
+	10 08	*Longitude*
-	03 32	*Equation of Time*
=	$13^{h}\ 06^{m}\ 36^{s}$	*Shadow due north*

Physical checks on the accuracy of the predictions

It was felt desirable to carry out some physical checks of the predictions, in order to identify any gross errors. As it was not possible to check on a May 09, a date was selected when the Sun's declination was close to its declination on May 09. The closest date was 1994 August 04, but because of cloud most of the observations were carried out on August 06.

The method selected was to set up a one-metre high metal rod as a gnomon. Four sheets of plywood were laid on levelling supports on the ground, so that the predicted shadow path would fall on them successively throughout the day. Care was taken to ensure that the top of the rod was exactly one metre above the plywood platform, and to ensure that the rod was upright. Much time was spent on levelling the platform, and this proved to be the most difficult part of the operation.

The experiment was carried out at the Observatory, as its position was accurately known, the direction of true north was already established to a high degree of accuracy (the 14-inch telescope is permanently mounted and aligned with true north to a fraction of a degree), the site has good visibility of the path of the Sun, and, most importantly, the experiment could be left undisturbed for several days. The experiment was conducted by Daniel Cave and myself.

The direction of True North was established with a compass, the magnetic variation of 4°37' West being determined by consultation with the Ministry of Defence Hydrographic Office. A visual check was made with Polaris. By these means we felt satisfied that the north direction was established to within about half a degree. The plywood platform was covered with blank newsprint, and the north direction line drawn on it.

Shadow lengths were measured with a metal tape, and directions with a large protractor. However, the centre point of the measurement was not easy to establish, as the side of the rod casting the reference side of the shadow moved during the day. Therefore, although the north direction was known to half a degree, and while angles could be measured to one degree with the protractor, the uncertainties in the reference point created larger errors.

Accurate time was obtained by the use of a clock controlled by the MSF radio signal transmitted from the National Physical Laboratory, Teddington.

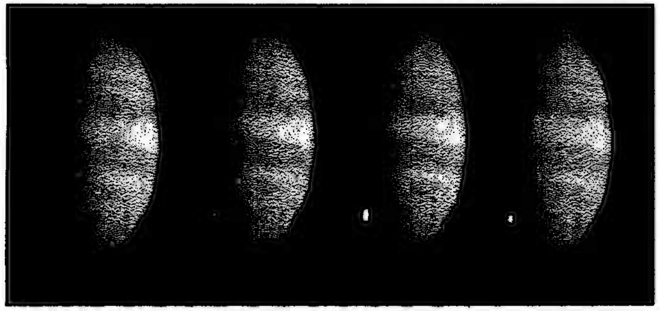
The early morning observations were not only hampered by haze, and therefore a diffuse shadow, almost impossible to see at times, but also by the inherent nature of the shadow cast by a tall gnomon, ie the dominance of the penumbra. Measurements were therefore not easy.

Nevertheless, the observations accorded with the predictions, within the limits of the inherent inaccuracies in the experiment. The observations did not, however, prove that the predictions were correct, especially to the close tolerances required for the Liberation Monument. ¤

David Le Conte

This article will be continued with considerations of the shape of the top of the obelisk, the time of surrender of the German armed forces, the shadow in future years, and the accuracy needed in the construction of the Monument.

The View from 150 Million Miles



Galileo spacecraft view of SL-9 fragment W collision with Jupiter.

Cast your mind back to the week in mid-July that had every amateur astronomer in the world watching the same object. We were all glued to the eyepieces of telescopes observing Jupiter as fragments of comet Shoemaker-Levy 9 collided with the planet.

Meanwhile another telescope, that on-board the Galileo spacecraft, was getting a completely different view of events. En route and at a distance of 'only' 150 million miles from the red planet Galileo was able, unlike Earth based observers, to see directly the impacts as they occurred. The spacecraft took many images of the events during that week, but we are only now beginning to be able to see the results. This is because the high speed communication link with the spacecraft is not working, and so data have to be transmitted back to Earth by a much slower backup antenna. The process of returning all the images will take six months to complete.

The sequence shown is quite impressive. It shows the collision of comet fragment W and spans a 7-second period. The frames show that the impact occurred at about 44 degrees south latitude, on the dark side of the planet. Fragment W collided with Jupiter on 22 July 1994. Brightness measurements of the earlier impact K have also been returned from Galileo. These measurements indicate that an intense burst of light occurred during the impact which lasted for about 40 seconds.

The remainder of the SL-9 information will be returned during the coming months as Galileo approaches Jupiter. It's primary mission is to study the Jovian system from orbit during 1995-7, but it has had a busy trip so far. ¤

Daniel Cave

Understatement?

From *"Comet Shoemaker-Levy Collides with Jupiter: The continuation of a unique experience"* by R M West, European Southern Observatory:

"SL-9 is no more. By its glorious death it has provided us with an unequalled and exciting opportunity to analyse the Jovian atmosphere. It has also enabled us to learn what they do to each other when they collide at 60 km/sec.

When asked what the preliminary information from this event can tell us about a similar one on the Earth, Mike A'Hearn, the summary speaker at the IAU General Assembly sessions on SL-9, said that there is now little doubt that a cometary impact of the same nature and dimensions would not dissipate much energy in the upper atmosphere and that it would obviously reach the Earth's solid surface and produce the associated effects. The continued study of the SL-9 observations will most certainly also cast more light on this very relevant terrestrial problem." ¤

Perseid meteors

In the last issue of Sagittarius Geoff Falla gave an account of the Astronomy Section's Perseid meteor count held in August, including the observation of a fireball. Members, especially those who participated, will be interested in the following letter, dated 1994 August 24, received from Alastair McBeath of the Meteor Section of the Society for Popular Astronomy, to whom the Section's observations were sent.

"Dear Geoff,

Thank you very much for your Perseid observations and letter. I'm very pleased to see that you enjoyed some good observations. In many places in Britain, it seems conditions almost did a repeat of 1993 - August 11-12 mostly cloudy except in the north but August 12-13 rather better generally. August 13-14 was also reasonable too.

Unfortunately, I have no other reports of your fireball seen at 23:05 UT on August 12. Sites in southern England seem to have suffered considerable amounts of cloud on August 12-13 generally, judging from comments (and the lack of observations) I've seen so far.

The latest information I have on the Perseids is that another outburst did take place, producing a ZHR of [about] 220 around 10.45-11.00 UT on August 12, over the western USA. This was a little later than expected (originally the primary peak was due at [about] 10h UT); it was also shorter and lower than in the past few years. Further results are coming through, so this news can be treated as preliminary only, but this does suggest the Perseids haven't given up quite yet! European results indicate that we caught part of the "traditional" maximum on August 12-13, when the ZHR was [about] 100-120, much as normal. Your own observations tend to further confirm this.

SPA results are coming through thick and fast now, so anything I say is subject to later updating, but the corrected mean magnitudes for the Perseids and sporadics respectively are presently +2.75 and +3.81, from 544 and 159 reliably-seen meteors. The mean LM for these is +5.7. 34% of Perseids and 6% of sporadics left trains. These figures are fairly typical, the Perseids perhaps a little fainter than usual, but nothing too significant. There do seem to have been fewer fireballs reported so far, even with your data, but there may be some more still to come. Overall, we've had nearly 1500 meteors reported for August to date, and I'm hopeful that we may double that when all the reports are in.

The Moon is a conderable nuisance again, preventing watches at the moment, but I'm hopeful of being able to get something more done in August for the start of the Section's Aurigid plotting project early next week. August to date has not been the greatest of months here, but far better than the rest of the year so far. I have managed watches on four nights, including August 11-12 (40 minutes!), 12-13 and 13-14, with reasonable numbers of meteors around on all three occasions. I hope that September doesn't follow the pattern of the last two years, since it's become one of the cloudiest months here, after having been one of the best for many years.

Many thanks again for your continued support. Best of luck with your next observations, and all good wishes.

Alastair McBeath"