Advertisements

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

Campaign for Dark Skies

We have received a letter from the BAA Campaign for Dark Skies. Within the astronomical and lighting community, and in Government, there is now a general awareness of the problem of skyglow. The Department of Transport has published a booklet *Road Lighting and the Environment*, for local authorities, recommending environmentally sensitive lighting.

The Campaign is aimed at achieving reductions in light pollution by the use of:-

* Modern full-cutoff light fittings.
* The right amount of light for the task.
* Controls on floodlighting.
* Security lights triggered by infra-red.

The Campaign have over 30 regional representatives, but are seeking officers all over the UK and Channel Islands. They are therefore asking if anyone in Guernsey would like to act as an officer to:-

* Raise the awareness of politicians, schools, etc. to light pollution.
* Draw attention to light pollution in the media.
* Other relevant activities.

Any member interested in acting as the Guernsey representative should contact Geoff Falla, the Section Secretary.

This issue of Sagittarius has kindly been sponsored by

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Astronomy Section Officers

Section Secretary:	Geoff Falla	Tel. 724101
Honorary Treasurer:	Peter Langford	720649
Education Officer:	David Williams	725088

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

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Sagittarius

The Newsletter of the Astronomy Section of La Société Guernesiaise

March/April 1994

Forthcoming events

La Société Guernesiaise Annual General Meeting
Wednesday, 2nd March
7.30 pm at St. Martin's Hotel

Public Star Nights and Telescope Surgery
Tuesday - Friday
15th - 18th March
7.00 pm (for 7.30 pm)
at the Observatory

The Microwave Background Radiation by Antony Saunders
Tuesday, 26th April
8.00 pm at the Observatory

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Bright Deep Sky Objects in Auriga
March/April star chart

Public Star Nights . . .

Starting at 7.30 pm each night from Tuesday the 15th to Friday the 18th March the Section will be holding **Public Star Nights** at the Observatory. These have proved very popular in the past, and all members are encouraged to come and help. Even if you know little of the subject, your help is needed to sell publications, ensure people sign the visitors book, serve teas and coffees. There is a job for everyone; so come along - **at 7.00 pm for a 7.30 pm start**.

The Moon will be approaching first quarter, and the Orion Nebula will be well placed for observing - it looks superb in the 14-inch telescope. There will lots of other objects also. Let's hope it's clear!

. . and Telescope Surgery

On the same evenings we will encourage anyone with a telescope, but who has difficulty in using it (because there is something wrong with it or for any other reason), to bring it along so that we can advise on its use. Last year we ran our first Telescope Surgery, and a number of people were thrilled to find that a simple adjustment or demonstration was all that was needed. Several saw through their telescope for the first time!

The Microwave Background Radiation

At 8.00 pm on Tuesday, 26th April at the Observatory, Antony Saunders will talk about a subject which has been much in the news lately, with the dramatic results from the COBE spacecraft. Antony will discuss the discovery and implications of the "afterglow of creation".

Educational activities

On Thursday the 20th January David Le Conte gave a talk about the Moon at La Houguette School, including slides, demonstrations and computer programs. The children's scheduled visit to the Observatory that evening to observe the Moon had to be postponed because of cloud. The visit was rescheduled for the 22nd February, but cloud again intervened.

On Monday, the 31st January 20 girls from Blanchelande College had clear skies at the Observatory, and enjoyed excellent views of the Orion Nebula, Andromeda Galaxy, double stars in Orion and Gemini, and were shown a number of constellations and the Milky Way. The visit was organised by David Williams. Geoff Falla, Roger Chandler, Bert Ozanne and David Le Conte were on hand to help.

Space history

On Tuesday, the 22nd February a dozen members heard Section Secretary Geoff Falla talk on one of his favourite subjects, the exploration of space. His lecture was divided into four parts: the early history up to 1957; the period from the launch of the first satellite in 1957 up till 1977 (during which the inner solar system was explored); the start of the the exploration of the outer solar system in 1977 to the present day; and an Apollo 11 slide sequence with audio cassette narration.

Geoff told us about dozens of landmark dates, from the invention of fireworks by the Chinese in 850 AD, to the recent space shuttle flight to repair the Hubble Space Telescope. He showed a lot of slides, including some of the earliest eplorations of planets, and many original newspapers recording the most exciting events.

Annual Business Meeting

* **Solar telescope to be built**
* **Observing on Friday evenings**
* **Public to be invited to observatory**
* **Section to join the BAA**

On the 25th January, 10 members attended the Astronomy Section's Annual Business Meeting, and held a wide-ranging discussion. Geoff Falla, Peter Langford, David Williams and David Le Conte were re-elected as Secretary, Treasurer, Education Officer and Editor, respectively.

Peter presented a good financial picture for 1993. The efforts of members to raise funds for the Section, through sponsorships, special events, star nights, and sales resulted in income of £676 (compared with just £152 in 1992). Subscriptions, at £133 were well up on 1992. Expenses were well controlled, despite the needs of the new building, and so we enter 1994 with a healthy bank balance.

Nevertheless, the Section clearly has significant expenses ahead, if we are to realise some of our ambitions of improving the observing facilities. A number of exciting projects have been suggested. **So ideas are needed for raising additional funds.**

In the short term **it has been decided to build a solar telescope.** This project, proposed by Lawrence Guilbert, will consist of two specially made six-inch mirrors - a flat heliostat (which will track the Sun) and a concave focussing mirror. The system will be set up outside the main building, and will project an image of the Sun through the window onto a screen. The cost, based on a quotation from a UK supplier, is estimated at £150 - £200.

Members agreed with Geoff Falla's proposal that regular observing be carried out on Fridays. If clear, therefore, **someone will be at the Observatory on all Friday evenings, after dark, and all members are welcome.** Note that this arrangement only applies if it is clear. If in doubt about the weather, call Geoff or the Observatory. The regular Tuesday evening meetings will continue regardless of the weather. Any member who is interested in observing on a night other than a Tuesday or Friday may continue to do so, and may contact another member if they wish.

There was considerable discussion about public access to the Observatory. **It was agreed to open the Observatory to the public, on Tuesday evenings after 9.30 pm from April to September.** A contribution of £1.00 (children 50p) to Section funds will be requested. Other Société members and visitors to the Island will be especially welcome.

Now that the Section has a fully established astronomical observatory, with equipment suitable for more serious work, **it was decided that the Section should join the British Astronomical Association.** This will give us the benefit of the knowledge of the Association's many specialist sections, and provide the Section with greater national recognition. It is an important decision in the development of the Section, and heralds our real "coming of age".

John Taylor proposed that an additional mount be provided within the C14 building - perhaps a German equatorial mount for the C11 telescope. There was also some discussion about the refurbishment of the C14.

»»

Longer term projects, proposed by Rex Huddle and David Le Conte, respectively, were a workshop area and a CCD camera. The **workshop** would involve enclosing and roofing the area currently occupied by the run-off roof. It would provide space for optical projects, a storage area, and possibly a dedicated darkroom. It would also provide increased security for the C14 building. The cost would be a few hundred pounds.

The future of this project depends to some extent on the interest of members in working on telescope building and instrument development, so **anyone interested in pursuing these ideas should get in touch with Rex (telephone 721919) or Geoff Falla.**

The **CCD camera** would enhance the Section's ability to gather data by providing an imaging capability. CCDs are proving their worth in reaching faint objects with short time exposures, and in providing images which can be computer processed. The camera would be used with the C14 telescope (or any other telescope), and would cost about £1500.

Other discussions centred on a request from the Campaign for Dark Skies for a Guernsey representative (see separate article in this issue), the outstanding work required to the existing buildings (volunteers required!), and projects to build a man-size celestial sphere framework and a large wall-mounted planisphere. Finally, thanks were expressed to Rex Huddle for his excellent work in cleaning the Observatory each month before our formal meetings.

An encouraging meeting, promising interesting times ahead for the Section. ¤

Strange lunar corona

Geoff Falla reported in the Winter issue of La Société Newsletter the unusual corona seen on the 21st December 1993. The Moon was surrounded by a yellow disc with a distinct orange rim, and this was surrounded by a blue ring. Such coronae are interference fringes caused by the diffraction of light by the drops of water in clouds, similar to those seen in oil spills.

Stars over the Falklands

You may have seen ornithologist Tim Earl's article in the Guernsey Evening Press Weekender about the natural history expedition to the Falklands. He mentioned the star charts and notes which we had provided. We have received a postcard saying that they had one clear night, and saw the Southern Cross, the Orion Nebula, α Centaurus, β Canis Majoris, and an upside down Moon. They also saw the Large and Small Magellanic Clouds, accompanied by the "drumming" of Magellanic Snipe.

. . . and over Bahrain

As we flew into Bahrain's Manama airport, it was surprising to see a bright star high in the sky and realise that it was Sirius. Orion was almost overhead, and the first quarter Moon lay flat on its back as it sank towards the western horizon. At this latitude of only 26°, the Pole Star was only half as high as seen from Guernsey, and twilights were sudden and short.

Regrettably, the bright Moon, the severe light pollution and haze did not assist serious observations, although we did see a strong lunar corona, coincidentally on the same night as the one seen from Guernsey.

DLC

Spectral types - star classification

Our Sun is classified as a G2 star. That means that its surface temperature is approximately 6,000 °C, is yellow in colour, and has metallic lines of great intensity in its spectrum.

So, what does all this mean?

The classification was developed by E.C. Pickering and Miss Annie Cannon in 1885. They based the classification upon the characteristic lines and bands which appear in stellar spectra, indicating the chemical elements present in the stars. They also used the surface temperature as an indicator. As a result, their main classification is as follows: O, B, A, F, G, K and M, with O class stars being the hottest and M class stars the coolest.

Each of these classes is further subdivided by a numerical system. For example, the Sun is G2.

The table shown below is known as the Harvard Classification, because it was developed at the Harvard Observatory. However, this is only part, albeit the dominant part, of a larger classification which extends from A to Q.

Approximately 99% of all known stars can be classified according to the series.

You may be interested to know that an earlier classification based upon colour was devised by the Italian A. Secchi, who grouped them as follows:-

White	(I)
Yellow	(II)
Orange	(III)
Red	(IV)

The Harvard Classification remains the basis for stellar classification today, over 100 years after its development. Spectral analysis has, of course, come a long way since its development during the last century. By careful analysis of stellar spectra we can determine: chemical elements present, temperature, velocities, rotation and absolute magnitudes.

The spectral lines or bands referred to when viewed are either dark, indicating absorption, or bright, indicating emission.

¤

David Williams

Reference:

The Penguin Dictionary of Astronomy, Penguin Books, 1966

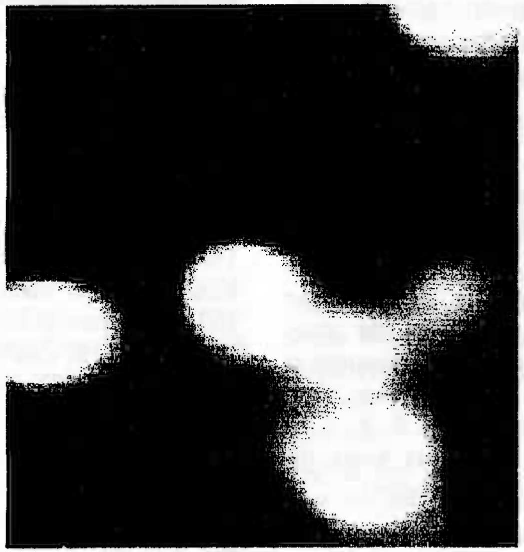
The Harvard Classification of Stars

Type	Surface Temp.	Colour	Spectral characteristics
O	50,000 °C	White	Lines of ionised helium seen
B	20,000 °C	White	Lines of hydrogen and helium
A	10,000 °C	White	Series of hydrogen lines
F	7,000 °C	Yellow-White	Metallic lines seen, eg Calcium
G	6,000 °C	Yellow	Intense metallic lines
K	5,000 °C	Orange	Molecular bands appear
M	3,000 °C	Red	Bands of titanium oxide seen

What lies at the Galactic Centre?

by Daniel Cave

Until recently the Milky Way's core remained unobservable, hidden behind the dense clouds of interstellar material that lie between us and the galactic centre, 28,000 light years away. This material dims the visible light reaching us from the centre by about one trillion (10^{12}) times (or by 30 magnitudes), meaning observations made at these wavelengths reveal little of the core. Almost nothing was known about the processes going on in the nucleus of our own galaxy, and it was not long ago that more was known about the mechanisms in other galaxies. Fortunately, in some other wavelengths the interstellar material is not opaque. The more penetrating radio and infrared wavelengths can get through, and it is observations made in these regions that are beginning to reveal the confused structure of the galaxy's heart.

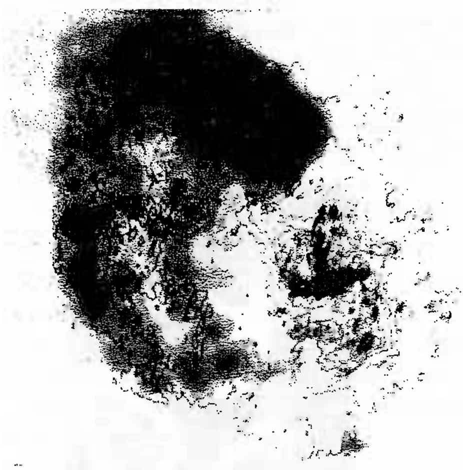


Infrared emissions of the IRS 16 area

Karl Jansky first detected radio emissions from the middle of our galaxy in the 1930s. Since then radio astronomy has rapidly evolved, and today huge radio dishes, linked together to form interferometers, are capable of phenomenal sensitivity and resolution. Radio astronomers were the first to begin to probe the galaxy's core.

A short time ago (c1970) infrared astronomy was not really possible. Then single element electronic detectors became available for use. Images using these detectors had to be made by scanning the object being observed. The picture would be made up point by point, a very time consuming process. Fortunately the semiconductor age came to the rescue with exotic variations of the CCD (charge coupled device) that were able to detect infrared radiation (silicon CCDs are not). This last step occurred at the end of the 1980s, and today infrared observations with CCDs are almost routine.

The observations made in the different spectral regions all seem to agree that there is a concentration of mass at the galactic centre. That, however, is all they do seem to agree on. The different observations tell different stories as to the exact nature of this mass concentration. There are two favourite theories explaining the galactic centre. The first is that it is an ultra compact cluster of O-type supergiant stars. The second suggests that the galactic centre conceals a black hole. The black hole theory has been gaining in popularity recently as the uncertainties in »»

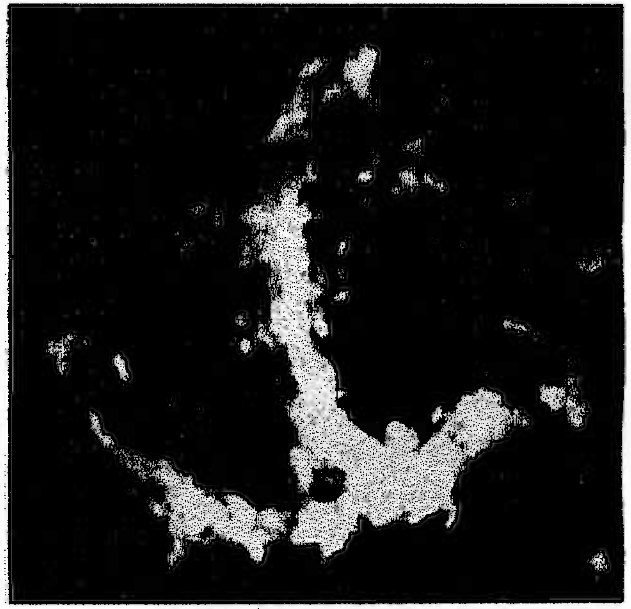


A grey scale map of the Sagittarius A region composed of data obtained at wavelengths of 6 and 90 cm. The spiral structure of Sagittarius A West can be seen to the lower right of centre.

measurements decrease, but presently they are still substantial and observations allow for either a black hole or a star cluster to exist.

In the radio region the very centre of the galaxy is dominated by a radio source known as Sagittarius A. The western part of this source, Sagittarius A West, has an interesting pinwheel structure to it and is about 10 light years in size. Near the centre of this spiral there is the compact radio source Sagittarius A* or SgrA*. Generally, astronomers believe that SgrA* is the true heart of the Milky Way galaxy.

In the infrared there are a number of condensed emitters in the same general region as SgrA*. IRS 7 (InfraRed Source number 7) is one such source. It lies close to SgrA* and is thought to be a red supergiant star. IRS 3 is another supergiant, but unlike IRS 7 it is embedded in a cocoon of dust. Two HII regions are also found nearby - IRS 1 and IRS 10. IRS 16 is a little more complicated as it is not a single object but has many components (IRS 16NE, IRS 16SW, IRS 16C, IRS 16NW). This is believed to be a luminous star cluster. These objects all lie within Sgr A West. Whatever the actual object at the galactic core is, the area immediately surrounding it is a very active one. Doppler-shift measurements show that there are ionised gas clouds moving with high velocities in the central five light years, a region which is otherwise empty. The high velocity of these clouds suggests that they are short lived, maybe lasting only a few »»



A 6-cm VLA (Very Large Array) radio image showing the curious spiral structure of Sagittarius A West. SgrA* is the condensed source to the lower right of centre.

thousand years. What is unclear at the moment is whether they are rotating around the galactic centre, falling into it or being ejected from it. If this material is being ejected from the galactic centre then this would sweep the central few light years and explain the absence of much material there. An outflow of material could also explain the excited hydrogen seen around the void's boundary, where collisions of the material with the surrounding neutral gas could be taking place.

A close look at IRS 7 could give an idea as to which object is causing the gas clouds to move in such a way. Radio observations have revealed a comet-like tail of material torn from IRS 7 that is streaming away from the galactic centre. From these images it looks as though SgrA* is the culprit, and must therefore be the central power source. However, lying between IRS 7 and SgrA* is one component of IRS 16, IRS 16NW which could also be responsible for these "core winds", so the situation is still slightly unclear.

Research carried out by radio astronomers tends to suggest the existence of a black hole, coincident with SgrA*, rather than a massive star cluster. Spectroscopic measurements made of material in the immediate vicinity (0.2 to 3.4 light years distance) of SgrA* suggest that it has a mass of 900,000 solar masses. Observations also show that it is no more than 20 astronomical units in size. This is typical of an accretion disk surrounding such a massive black hole. In addition to this, recent observations have recorded what could be SgrA*'s infrared counterpart. The properties of this infrared source agree well with those of a model containing a black hole of 500,000 to 1 million solar masses. Sadly, high energy observations do not tie in with this. X-ray and gamma-ray emissions are rather weak and suggest a 10,000 solar mass object at most.

SgrA*, possibly the energetic core of the Milky Way, is shown here with four ionised clouds surrounding it.

Some observations support the idea that the galactic centre contains a cluster of O-type supergiants. A compact cluster of such stars may be able to account for all the luminosity and gas flow observed in the central few light years without the need for a black hole at all.

So, the answer to the question "what lies at the galactic centre?" is presently still an open one. More observations need to be made with instrumentation able to resolve finer detail and detect still fainter objects. Then the models of the innermost regions of our galaxy need to be refined using these observations. »»

Astronomers are only just beginning to converge on an answer. While they are able to answer some of the questions regarding the galaxy's core, many more still remain: "What is the object at the galactic centre - a black hole, a star cluster or is it something else?", "What produces most of the energy?", "Does the observed excitation come from outflow of material, inflow of material, from stars or is it something else?", "Surely all this excitation can't come from a black hole.", "What part does the galaxy's magnetic field play in the central activity?".

The observations capable of answering these questions may have already been made or they may still be a few years off. One thing is for certain though. With the high speed at which new techniques are being introduced it won't be long before many of the questions are answered. ¤

Daniel Cave

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PICTURE CREDITS

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Sky and Telescope, December 1990, page 583


The Milky Way as it would appear if we were outside it. Note the central bulge where the stellar density is a million times that of the spiral arms.

Famous Lives - 1

This is a series of short 'pen portraits' of astronomers whose pioneering work has advanced our understanding of the cosmos, and made a lasting impression upon the development of astronomy.

Looking back through 3000 years or so, I have decided to choose the following (in my opinion) great astronomers:-

Ptolemy of Alexandria

Nicolaus Copernicus

Tycho Brahe

Galileo Galilei

Johannes Kepler

Sir Isaac Newton

Sir Edmund Halley

Sir William Herschel

Percival Lowell

Edwin Hubble

I would also like to add two other names to the list:-

Robert Goddard

Werner von Braun

The last two contributions were not specifically in astronomy, but their work in rocketry has opened up the window of the sky, allowing astronomers to work in space, satellites to explore other planets as well as our own, and of course more recently the Hubble Space Telescope to be placed in orbit.

It may be argued that others deserve to be included in the list, but these are my top 12. I hope you find the series as enjoyable to read as I found it to write. I begin with Ptolemy.

David Williams

Ptolemy of Alexandria (c90 - c170 AD)

Ptolemy, or to give him his full name, Claudius Ptolemæus, was of Græco-Egyptian birth. We do not know his exact dates, but most sources agree that those quoted above are fairly accurate.

It is important to remember that, strictly speaking, Ptolemy was not an astronomer; he was a mathematician and geographer. The other important factor to bear in mind is this: that the famous theory of cosmology bearing his name, ie the Ptolemaic system, was not his own work. It is based upon the writings of much earlier astronomers and philosophers, in particular Aristotle.

However, one thing is for certain: his writings influenced both the Arabs (later Islamic) and Christian western world for nearly 1500 years. As a result, scientific thought and ideas about mankind's place in the universe stood still, unchanging for all that time. This view of mankind fitted rather well with that of the developing Christian Church, and when Christianity became the dominant western religion, Ptolemy's ideas became accepted orthodoxy.

The Ptolemaic System may be summarised quite simply. Imagine the Earth to be in a fixed, immovable position at the centre of a finite universe (this is known as a geocentric system). All the heavenly bodies - stars, planets, the Moon - are in fixed orbits at various distances from the Earth, and they all revolve around the Earth once a day.

Place yourself in Ptolemy's sandals, or those of any other Greek, 2000+ years ago, and look up at the sky. It's fairly »»

obvious that we are not moving, but that everything else is - it all makes rather good sense to me. It also made good sense to everybody else for 1500 years, and it was not until Copernicus and Galileo dared to challenge the accepted teachings that any progress was made.

As I said earlier, this system was not formulated by Ptolemy. It was, in fact, originated by Aristotle, c400 BC. So, why is it known as the Ptolemaic System?

Ptolemy, to his great credit, collected together in one mighty tome the works of the ancient astronomer-philosophers, and presented it in 140 AD as the *Almagest*, which is probably his greatest work. For those of you interested in language, the name *Almagest* derives from various sources. Originally it was called *Hé mathematiké syntaxis* - The Mathematical Collection. This eventually became known as the *Megus astronomos* - The Great Astronomers. So, where does *Almagest* come from? In the 9th century Arab astronomers used the Greek *Megisté* - to describe his work, and prefixed it with *al* - it became *Almagest* - the Greatest. It is in this form that we know his work today.

It is because of the publication of the *Almagest* that Ptolemy's name was given to what was in essence the already well established (500 years or so) Aristotelian view of the universe.

This great work was stored at the famous Library in Alexandria, and was later translated into Arabic. It then spread throughout the Islamic world at a later date, and into Crete, where it spread through the Christian world.

I must not forget to tell you that he was also responsible for producing a catalogue of 1028 stars, showing their positions and magnitudes - no meant feat for the times in which he was working. It is also known that Columbus was greatly influenced by. another of his works, entitled the *Geographite hyphegesis*, Guide to Geography - and we know what Columbus did in 1642!

Ptolemy, then, must be regarded as one of the most influential thinkers/astronomers of all time. His works were to have a profound effect upon all thought about cosmology for 1500 years - longer than any other single piece of work. From our 20th century perspective we may view his work as one of the greatest stumbling blocks to cosmology in recorded history! However, is that a fair assessment? He provided a framework in which mankind could fashion a reasoned argument for his existence. It provided both a scientific and a philosophical rationale for our very being.

I must confess, I take my hat off to him, if only because the beauty of his cosmos lies in its simplicity - life is so complicated today. I wonder - do I hear Ptolemy saying the same thing? ¤

David Williams

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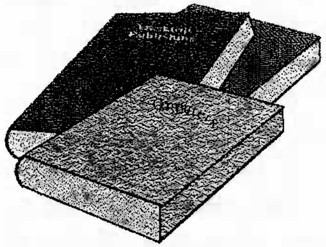
In the next issue, David will discuss another famous life - Nicolaus Copernicus.

Book Review

BAA Observing Guide



The British Astronomical Association Observing Guide is a 60-page booklet, containing 20 chapters, each written by a Director of one of the BAA Sections. Thus there are chapters on: observing the Sun, Moon, each of the planets, asteroids, comets, meteors, aurorae, variable stars, deep sky objects, astrophotography, astronomical computing, artificial satellites, historical and radio astronomy. A list of recommended further reading is provided for each chapter. At a price of just £1.50 it is excellent value.

The book not only gives guidance on how to observe astronomical objects, but also on what to observe - what to look out for, and particularly what kind of observations amateur astronomers can usefully carry out.

The list is impressive: sunspots, solar faculae, prominences and flares; transient lunar phenomena, lunar typography (especially the limbs), lunar occultations; disc details of Mercury, Venus and Mars, including the Martian polar caps, dust storms, atmospheric phenomena and dark markings; brightness variations of asteroids, occultations by asteroids; patterns of activity in the atmosphere of Jupiter; intensity and appearance variations in the features of Saturn, its rings and satellites, occultation of stars by Saturn and its rings; discovery, position and magnitude estimates of comets, physical appearance of comets, comet tails; meteor and aurora observations; monitoring of variable stars, patrolling supernovae; observing active galactic nuclei, measuring double stars and planetary nebulae; and studying variable nebulae. WOW!

This is followed by a chapter on photography of astronomical objects, such as star trails, the Moon, planets, Sun, and deep sky objects (i.e. objects beyond the solar system), and CCD imaging is mentioned. The chapters on computing and artificial satellites are very general. The chapter on research into the history of astronomy gives some useful information. There is a good description of the instrumentation needed for radio astronomy, and what can be done with it by amateurs, although the Association does not at present have a Radio Astronomy Section. The Telescope Technology Section (which includes instrumentation) gets a brief mention.

Each Section Director has his own style (there is not one female among them!). I felt that the booklet could benefit by having a standard layout for each chapter, ie objectives of the Section, reasons for observing, instruments required, how to observe, and examples of results. I would also have liked to see more on specific non-solar system objects.

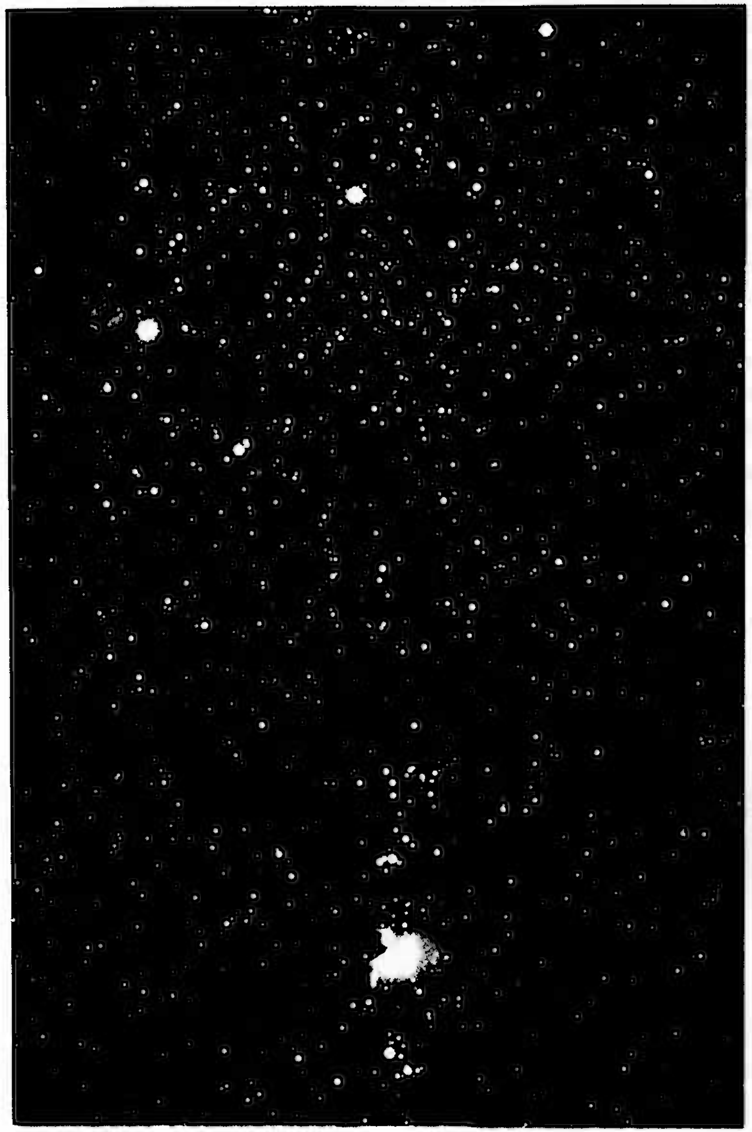
However, these are mere quibbles, and I would recommend the Observing Guide to anyone interested in more serious observing and pursuing their favourite subject. ***David Le Conte***

Note: The Section library holds a copy.

The Orion and Horsehead Nebulae

Daniel Cave's photograph shows a large part of Orion. The Orion Nebula, M42 is at the bottom of the picture. In the original photograph the four stars of the Trapezium asterism are visible, and the nebula is distinctly red in colour. Just above and adjacent to M42 is M43, the northern part of the Orion nebula, which is separated from the main part by a dust cloud. Above that is NGC 1973, a nebulosity, and the open cluster NGC 1981.

The three bright stars of Orion's Belt are at the top of the picture. From left to right they are: Alnitak, Alnilam and Mintaka (ζ, ε and δ Orionis). Below Alnitak, the Horsehead Nebula is faintly visible, and above and to the left of the star is NGC 2024, a diffuse nebula. Daniel took the photograph in December, using the 8-inch Schmidt telescope.



The Equation of Time

In the last issue I described the sundial as an astronomical instrument, and introduced the concept of the Equation of Time - the difference between the Mean Sun, used for clock time, and the True Sun. I explained that it was dependent upon two factors.

The first effect is the eccentricity of the Earth's orbit around the Sun, ie its deviation from a circle. Although the Earth travels around the Sun in an elliptical orbit, we may treat it mathematically as if the Sun travels around the Earth in a similar orbit.

While the Mean Sun moves uniformly as seen from the Earth, the True Sun travels at a speed determined by Kepler's Second Law. This states that the line joining the Sun and a planet sweeps out equal areas in equal times. This results in the True Sun sometimes being in front of the Mean Sun, and sometimes behind.

The time difference caused by this effect is called E_1 and is given by the equation:

$$E_1 = -7.64 \sin \omega (t - 2) \text{ minutes}$$

where ω is the mean angular velocity of the Earth in its orbit (= 360/365.35 °/day), and t is the number of days which have elapsed since the beginning of the year (the -2 is because the Earth is at perihelion, ie its closest point to the Sun, on 2 January).

The sine curve corresponding to E_1 is shown in the first graph on the next page.

The second effect is due the fact that the Sun's apparent path, the ecliptic, is at an angle to the equator of almost 23½°, because of the tilt of the Earth's axis. We therefore introduce the concept of a Dynamical Mean Sun, which moves along the ecliptic, and an Astronomical Mean Sun, which moves along the equator. The difference between these two Suns is called E_2 and is given by the equation:

$$E_2 = 9.863 \sin 2(RA) \text{ minutes}$$

where RA, the Right Ascension of the Sun, is given by:

$$RA = 0.9856\, t - 84.38$$

The sine curve corresponding to E_2 is also shown in the first graph on the next page. Note that it has half the period of E_1 because of the factor 2 in the equation.

The Equation of Time, E, is given by:

$$E = E_1 + E_2$$

and is shown as the curve in the second graph on the next page. It is the sum of the first two curves. When E is positive the curve is above the horizontal line (the x-axis), and the True Sun is ahead of the Mean Sun. When E is negative (below the line) the True Sun is behind the Mean Sun.

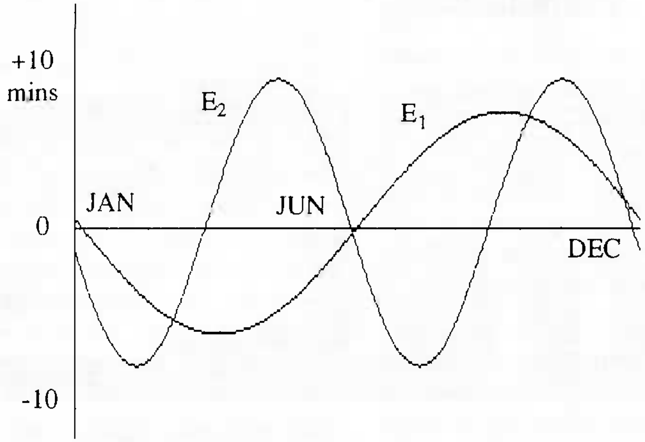
Thus, when E is positive it must be subtracted from the time shown by the sundial to get clock time, and when E is negative it must be added. The curve of the Equation of Time shown on some sundial plates is often inverted, to emphasise the need to "add" and "subtract". An example is shown in the photograph on the next page.

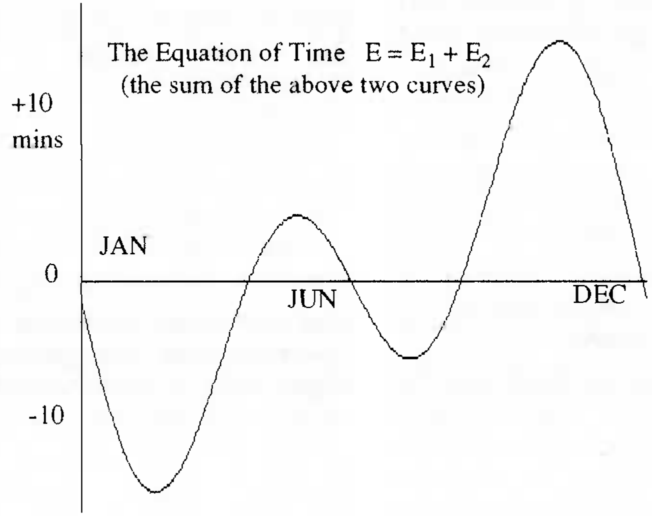
The Equation of Time varies between minus 14^m15^s (on 11 February) and plus 16^m25^s (on 3 November), and is zero only four days (16 April, 14 June, 1 September, and 25 December). Its daily value is given in a number of publications, including *Whitaker's Almanac*.

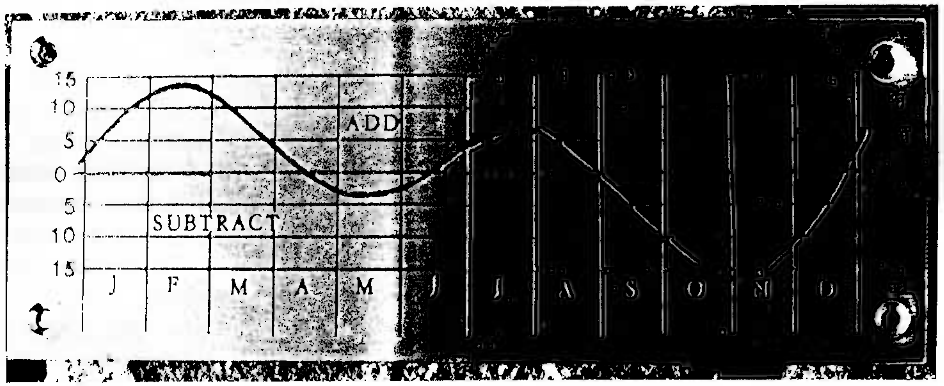
What would Passepartout have made of it?

David Le Conte

Curve E_1 The effect of the eccentricity of the Earth's orbit.
Curve E_2 The effect of the obliquity of the ecliptic.







Sundial plate showing an inverted Equation of Time

The Future of Planetariums

In the last issue I described the Christmas meeting of the British Astronomical Association, particularly a talk by Professor Wilmore about clusters of galaxies. This talk was followed (after a break for wine and mince pies, and a visit to the trade stands) with a talk by Martin Ratcliffe about the future of planetariums (or planetaria?).

Martin Ratcliffe, formerly of Armagh Planetarium, and now Director of the Pittsburgh Planetarium, spoke about trends in the design and use of planetariums. He started by conducting an audience survey, and found that 50% had visited a planetarium recently (compared with just 5% of American astronomy audiences!).

His talk was quite thought-provoking. He pointed out that traditionally planetariums have presented a view of the celestial sphere, but the challenge is to use the new technology to show the exciting views of space now being obtained.

Many planetariums use Zeiss projectors (Dr. Ratcliffe said the Minolta projector actually gives a more realistic night sky), but the Digistar projector is revolutionising planetariums. Although not giving quite as realistic star fields as the Minolta projector, its computer database of stars can be used in many ways to give more exciting and informative presentations.

For example, it is possible to "fly" through star fields to show them as three-dimensional, and this can be combined with video effects to create a feeling of virtual reality. It is also interactive - the audience can press buttons to influence the choice of object for further viewing.

The London Planetarium is planning to convert from its Zeiss projector to a Digistar, so we can expect to see some of these innovations closer to home.

The Pittsburgh Planetarium is part of the Carnegie Science Center. On the roof is a Ritchey-Crétien telescope, controlled from two floors below. Unfortunately, the Center (and the observatory) is floodlit! However, Dr. Ratcliffe knows where the switch is. He emphasised the joys and benefits of CCDs, for both serious work and pleasure observing. Even in light-polluted Pittsburgh it is possible to reach 14th magnitude variable stars in just two minutes.

Dr. Ratcliffe concluded by showing a beautiful picture of last November's total lunar eclipse, taken with an 11-inch Celestron on a German mount. Although Pittsburgh was cloudy, he was able to get first-hand weather information, and drove 200 miles to get a spectacular photograph, which even included a grazing star!

The final speaker was Martin Moberly on the 1992 observations of Comet Swift-Tuttle. Unfortunately, we had to leave, having thoroughly enjoyed the experience of our first BAA meeting, as well as meeting fellow amateurs (and professionals) from all over the country.

Dates of meetings are published in the BAA programme and newsletter, which are available at our Observatory. I recommend any members having time to spare in the UK to consider attending a meeting of the British Astronomical Association, especially as the Astronomy Section is now achieving affiliated membership of the BAA. ¤

David Le Conte

A visit to . . . St. Andrew's University Observatory

We had made special arrangements with Dr Hill of the Physics and Astronomy Department of St Andrew's University in Scotland, and were given an tour of the Department's Observatory by Pierre Manstead, a doctoral research student.

First we had to drive to the Observatory from the Astronomy Department at North Hall. The Department used to be based at the Observatory, but is now combined with the Physics Department. On arrival at the Observatory, close to the University playing fields just outside the town, we noticed that the former Department offices are now commercially let.

Observational programmes concentrate on stellar physics. One dome houses a 20-inch f/11 cassegrain reflector. This instrument is equipped with a cooled CCD spectrograph. It is used for variable star work, such as Algol type and Wolf-Rayet type eclipsing binaries. The research is used for studying effects such as the movement of the periastron point (ie the point of closest approach of the binary components). I was surprised to see that data gathering was accomplished with a simple BBC computer.

In the next building are twin 16-inch telescopes on a single mount. These have photomultiplier tubes for comparing stellar light intensities, again for variable star work. These telescopes were old friends, because I remember them at the Royal Observatory, Edinburgh in the 1960s. In light polluted places like Edinburgh and St Andrew's such stellar magnitude studies can usefully be carried out, rather than observations of faint objects.

There is also the 37-inch f/3 Schmidt-cassegrain James Gregory telescope, with an unusual off-axis fork mount. It was observing the W Ursa Majoris system of fast moving contact binaries. In the Napier Building is a 16-inch cassegrain, used as a photometry teaching instrument, and a 6-inch Zeiss coudé reflector - a beautiful looking instrument.

Pierre, our guide, suggested that we in Guernsey could do collaborative photometric work with a CCD on our 14-inch telescope. Something to consider! ¤

David Le Conte

BBC Television Series

We have received notification about a new television series to be shown on BBC1 in the autumn. The six 30-minute programmes will be aimed at an audience with no knowledge of astronomy. Topics will include: the Moon's phases, seasons, eclipses, latitude, longitude and time, and will "avoid all mention of black holes, white dwarfs and red shifts".

Each programme will contain a DIY element, such as astrophotography, drawing, projection of the sun, and naked eye observing. There will be a book to accompany the series, and viewers will be able to write in for an astronomy projects pack.

Of particularly interest to the Astronomy Section members will be a programme which features a public open evening, recording what people see and their reactions. A telephone number will be given to allow viewers to find out about open evenings in their area. Viewers will be sent a leaflet by the BBC giving addresses of amateur astronomy societies.

The Astronomy Section will be included in this information, and we plan to organise open evenings to coincide with the series. Further details in due course.

11-inch telescope work

John Taylor and Bert Ozanne have been working on the Right Ascension axis of the 11-inch Celestron, the setting circle of which had begun to seize up. Their work has made considerable improvement, and will make the telescope easier to use. Further improvements are planned.

Did you know?

The Sun produces its energy by nuclear fusion, and each time four hydrogen atoms combine to make one helium atom they lose 0.7% of their mass. This is lost in the form of energy. In one second the Sun loses four million tonnes of its mass in this way. But this incredible loss of mass has little effect on the Sun, as it weighs 2,000 million, million, million, million tonnes. Over the five billion years of the Sun's life it has lost only 0.02 of its mass in this way.

Antony Saunders

Sundials in Guernsey

In the last issue I described my new sundial, and discussed sundials as astronomical instruments.

I would like to identify all the ancient sundials existing in Guernsey, as well as any particularly good modern ones. Here are three to start with:-

The Mass dial on St. Saviour's Church.

St. Andrew's Church, The Grange.

The Douzaine Room, St. Peter's.

Does anyone know of others, or whether there exists any study of Guernsey sundials? It would be interesting to study their history and styles.

David Le Conte

Planetarium Pop

I was quite surprised and pleased to hear my daughter say that she been to the planetarium in Vancouver - until I heard that it was for a laser pop-group show!

DLC

Letter to the Editor

Dear Mr Le Conte

Thank you very much for the Jan/Feb 1994 issue of your Society Newsletter 'Sagittarius' which I found very interesting.

I shall give your Society a mention in the April issue of the BAA Newsletter.

It was a pleasure meeting you at our December 18 meeting - thank you for the write-up in 'Sagittarius'. I hope you will be able to get to some of our other meetings.

Best wishes to you and your members for a successful 1994.

Yours sincerely, Rossie Atwell,
British Astronomical Association

Rossie is Business Secretary of the BAA. She lives in Selsey - Patrick Moore's home town.

Letters have also been received from Section members Mark Humphrys (aboard a research vessel in the Gulf of Suez) and Daniel Cave (University of Hertfordshire). Mark says he is having fun, seeing coral reefs at close quarters. They had a severe storm in January and lost two boats. Daniel sent further information about CCD cameras, and more superb photographs taken with the 8-inch Schmidt telescope. Daniel's excellent photograph of Jupiter with the shadow of Io, taken with our 14-inch, was published in the March issue of *Astronomy Now*, with due mention of the Astronomy Section. Congratulations Daniel!

Heavenly harmony

I was recently asked about the "Music of the Spheres", by one who was interested in music and knew that I was interested in astronomy. It was a concept of the 6th century BC Greek philosopher Pythagoras.

Chambers Twentieth Century Dictionary defines it as *"the music, inaudible to mortal ears, produced according to Pythagoras by the motions of the celestial spheres in accordance with the laws of harmony."* Aristotle (384-322 BC) said that the Pythagoreans (the followers of Pythagoras) conceived that *"the whole heaven is harmony and number"*, and that they claimed the sounds could not be heard because they were there from the moment of our birth.

Hippolytus said that Pythagoras maintained that the universe *sings*, and is constructed in accordance with harmony, and that he was the first to reduce the motion of the seven heavenly bodies (ie the Sun, Moon and the five known planets) to rhythm and song.

The Pythagoreans believed that the slower moving celestial bodies made a deep sound and the faster ones a high sound, and that their distances and speeds were in proportions which produced a musical harmony. This was a natural consequence of the observation that moving bodies produced sounds.

However, Aristotle argued that we hear no sound because there *is* no sound, and he went on to "prove" that the stars did not move through the air.

David Le Conte

Reference: *Greek Astronomy* by Sir Thomas L. Heath, Dover Publications Inc. 1991 (first published 1932)