GNOMON

Newsletter of the Association for Astronomy Education

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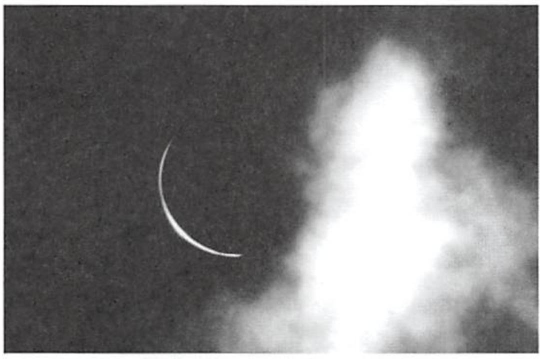
## That darned solar occultation

The RAS obviously knew something we in Cornwall did not by sending their main eclipse observation party to Alderney in the Channel Islands! Gnomon's astronomer in Hawaii went one better though: Stuart Ryder went to Turkey and had a perfect view

He writes: this was a spectacular eclipse, even if lasted only 2 minutes. The things that stick in my mind are the number of prominences (and the fact they were all visible throughout totality), and the "spiky" nature of the inner corona. In the surrounding sky I could see only Venus, despite looking for more objects. From our vantage point on a hill overlooking the town of Tokat, we got an excellent impression of the shadow sweeping in from the NW, rapidly darkening the hills and valleys before it swept over us, and then it moved away, progressively uncovering more hills. It added a nice 3-D effect to it.



***A strange shadow on the lower clouds, seen in Alderney just before totality (photo: Alan Pickwick).***

After underexposing most of my wide-field shots from the Caribbean last year, I managed to overcompensate this year, and overexposed them all this time. Serves me right: next time I won't bother taking any! The current opinion in our group for 2001 is that maybe a South Atlantic cruise (not exactly the busy season), as most of the African countries are even more dicey than Turkey

Please bombard Stuart with e. mails expressing your jealousy! He avoided the dreadful earthquake that followed (the eclipse and earthquake in Turkey are the sorts of coincidences which boost pseudo-science.)

The most amazing feature of the eclipse in Penzance was that the weather was absolutely perfect the day before and the day after. On the 11th, the clouds were not just thick, they were black as the ace of spades and appeared to be preparing for a thunderstorm - and that was before it started to show the effects of the eclipse above the clouds. However, it was a unique occasion from several points of view. The pre-totality wind was very marked, and suggests that those who are not yet convinced ought to be! Birds, far from roosting, went mad! The seagulls made more row than ever until the light returned. They were obviously of the ancient Chinese persuasion about the dragon devouring the Sun and did their bit to scare it off (and of course, it worked!). The best of all was the amazingly ghostly eastwards passage of the Moon's shadow as it zipped across Mount's Bay after third contact, visible even through the clouds.

### Meanwhile in Alderney

Alan Pickwick was in the Alderney party and saw plenty through the gaps in the clouds! He set up his contributions to the experiments

**GNOMON** - definition from the **Concise Oxford Dictionary:**
Pillar, rod, pin or plate of sundial, showing time by its shadow on marked surface, column, etc. used in observing Sun's meridian altitude.

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### Publication Dates:

These are at the equinoxes and the solstices, that is four times a year.
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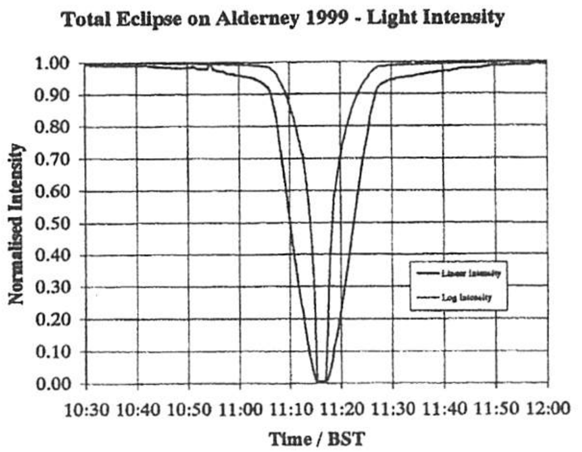
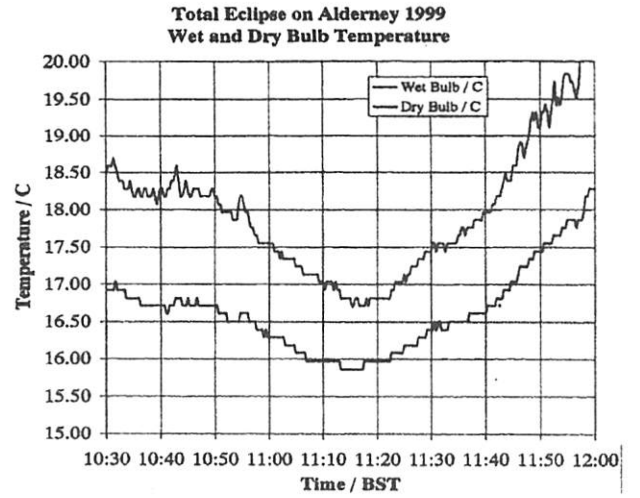
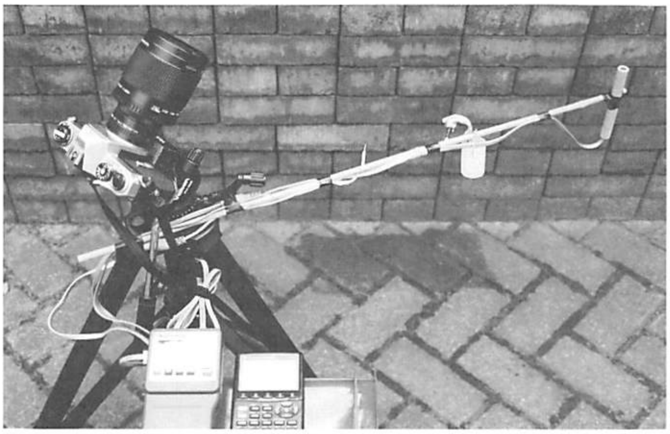


***Alan Pickwick's SLR camera as set up to take the photograph on page 1, together with the light and temperature measuring equipment.***

which he described in the last issue of *Gnomon* and some of the results were spectacular. The graphs show the variation of light intensity and temperature, recorded at Fort Albert on Alderney.

The eclipse started at 09:59, reached maximum at 11:16 and ended at 12:37. The intensity was recorded using a silicon phototransistor probe, mounted to look at the zenith. The data was collected using a Texas Instruments CBL (Computer Based Laboratory) data logger set to sample every 20 seconds.

The sky was a patchwork quilt of clouds, allowing the Sun to be seen most of the time. Alan saw the chromosphere and some prominences. "The corona was so bright", he said, " I thought the eclipse had ended early!". Lucky for some!

## Plea for promotion of the AAE

The AAE should be promoted wherever possible, especially in Science Centres and other Societies, stressed the Association President Alan Pickwick, speaking at this years' annual business meeting. He congratulated the ASE and Sheffield Hallam University for their continuing encouragement and support.

The meeting took place on the 26 June at Techniquest in Cardiff. Alan Pickwick, reported on a number of items including the recruitment pack. This was sent out with the last edition of Gnomon with a request to readers to pass the 'friends' pack on to someone interested in joining the Association. At the moment it is not possible to quantify the results but thanks were extended to everyone who participated in this drive.

The meeting then heard the annual reports from the Treasurer, Secretary and Vice President. Following this, elections to Council were held. There were no new nominations and those wishing to stand for a further year were duly elected. Two of last years' Council resigned: Alex Barnett, is now the permanent Creative Director of the National Space Centre in Leicester, and Dave Gittens, is taking time out to finish his Open University studies.

Two members from the floor expressed an interest in serving on the Council and it was decided to coopt them at the next Council meeting in September. averaged a question a week this year and Mike is happy to continue providing this service to interested parties (see "The Questions People Ask"). A very pleasant buffet lunch was provided by Techniquest, which everyone enjoyed before spending the afternoon being shown around the sights and sounds of Techniquest by Bill Dines. Thank you very much to you and your staff Bill, the day was truly memorable.

**Jean Collins** (Secretary)
*jeancollins@compuserve.com*

## GCSE astronomy course at the RGO

Adults with an interest in astronomy will be able to study for a GCSE in astronomy from this October at the most famous observatory in the world: the Royal Observatory Greenwich. This special Open Museum course aims to prepare students for the examination over a period of nine months.

Topics will include the Earth and Moon, the solar system, stars, galaxies and observing techniques. Students will be able to use the observatory's 28-inch refractor, the seventh largest of its type in the world, and a Meade LX10 Schmidt Cassegrain telescope. Astronomical events which can be seen this year include a possible Leonid meteor storm (see "Sky Diary"), a total lunar eclipse (2000 January 21) and the Sun at sunspot maximum.

Assessment will be primarily by examination in June 2000 (although students who do not wish to sit the exam will also be welcome). Practical project work, some of which can be carried out using equipment at the Observatory, comprises 25% of the assessment. The tutor for the course will be Dr Robert Massey, Astronomy Information Officer at the observatory.

The fee is £100 for the three terms , which begins on 6 October (7pm - 9pm). Please note that the course fee does not include the cost of the examination fee (£27), which is payable during the spring term. Students on low income are eligible for a reduction (tel. 0181 312 6772).

For a free Open Museum prospectus or further information, contact Joy Affection on 0181 312 6747. Further information is also available on the NMM web site: http://www.nmm.ac.uk.

### Dark skies moved

Please note that the British Astronomical Association's Campaign for Dark Skies website has been changed.

The new site is at :

http://www.dark-skies.freeserve.co.uk

Please amend your records accordingly, and inform others if necessary.

Thank you.

**Bob Mizon**, Coordinator.
(*bob@mizar-astro.freeserve.co.uk*)

# Observations

## Spode defined

As a Cornish astronomer who had, during several days of work, prepared all sorts of equipment ready to observe the August 11 eclipse of the Sun, I feel it is about time someone quantified Spode's Law, which states (roughly) that the chances of your seeing an astronomical event without spending thousands of pounds in round the world travel is inversely proportional to amount of interest raised to a power which varies as the reciprocal of its rarity, and tends to zero at all times due to the typical value of almost any of the variables.

It was discovered in a rare manuscript by Dr. Erasmus Spode (1799 - 1803) dictated on his death bed, so rumour has it, to his mother.

$$\alpha = \frac{\varepsilon . D . x}{F^{1/n} . i^2} \times 100\%$$

where $\alpha$ is the chances of seeing a specified astronomical event, expressed as a probability; $\varepsilon$ is the state of your eyesight, expressed as a percentage of the population of your neighbourhood whose eyesight is worse than yours; D is the availability of data, and is equal to h (Planck's constant)* or unity (depending on whether you were you aware it was going to happen or not, respectively); x is the number of times the specified event will be visible from your location during the rest of your lifetime; F is the astronomical "fun quotient" expressed as the number of hours you would be prepared to stay awake to be able to see the event, starting from sunset; n is the average number of occurrences per day of such an event as seen from where you live; and i is the total amount of media misinformation and rubbish (such as this item! - *Ed*) published about the event since the beginning of time, in column inches equivalent .

* Spode called *h* "Plonker's constant"; its more universal application was discovered later by Max, who, naturally, renamed it to suggest he had managed to discover it, even though it was very small.

# Letter from Hawaii

Aloha! As 2000 approaches, Mauna Kea continues to be a very busy place. The end of June saw the official dedication of the recentlycompleted Gemini North 8m telescope. Among the distinguished guests present for the occasion was HRH Prince Andrew, representing the United Kingdom which is a 25% partner in the Gemini project. While in Hawaii, Prince Andrew took the time to visit the two other telescopes on Mauna Kea in which the UK has an interest: the United Kingdom Infrared Telescope (UKIRT), and the James Clerk Maxwell (submillimetre) Telescope.

One of the things that enables older telescopes such as UKIRT to remain at the forefront of astronomical research is the continual improvements in attached instruments. For the past 5 years, the workhorse infrared camera on UKIRT has been IRCAM3, which has an array of 256x256 pixels and a field of view slightly more than 1 arcminute (1/60th of a degree). Nowadays, high quality infrared arrays with 1024x1024 pixels can be produced, and one such array is at the heart of our next generation infrared camera, known as UFTI. The larger array allows us to resolve even more detail than ever before, as well as observe an area 60% larger. Although IRCAM3 has now been retired from service, it is not destined for a museum or the scrapheap; it will be cannibalised to provide parts for another camera optimised for observing at longer wavelengths than UFTI.

The photograph on the front page of the last issue showed the galaxy M104 in Virgo, also known as the "Sombrero" galaxy on account of its resemblance to a Mexican hat. It was obtained using UFTI and, because UFTI can see only 1/20th of the galaxy at one time, the image had to be built up using a mosaic technique, in which several overlapping images of different parts of the galaxy were stitched together in software to produce one large map, so that the joins between individual frames are almost invisible.

Many readers may have seen optical pictures of this galaxy, which is dominated by the thick dust lane seen in silhouette against the extensive bulge and almost edgeon disk of stars. Even though this image was taken in infrared light, which has an easier time penetrating the dust, the clumpy nature of the dust still causes significant obscuration, and preserves the distinctive Sombrero appearance.

To see other beautiful examples of what UFTI is revealing about the infrared universe, feel free to visit our Image Gallery on the World Wide Web at:
http://www.jach.hawaii.edu/JACpublic/UKIRT/public/gallery.html

This will be my final "Letter from Hawaii" as I will soon be leaving Mauna Kea and the Big Island to go and work for UKIRT's cousin in Australia, the AngloAustralian Telescope. I look forward to maintaining my contacts with *Gnomon* through future "Letters from Australia".)

**Stuart Ryder**
Joint Astronomy Centre: *sryder@jach.hawaii,edu*

# For Your Library

*A Skywatcher's Year.* Jan Kanipe. Cambridge University Press. 189pp. ISBN 0 521 63405 9 (paperback) £11:95.
*The Monthly Sky Guide* Ian Ridpath; Wil Tirion. Cambridge University Press. 64pp. ISBN 0 521 66771 2 (paperback) £9:95.
These are two fairly short familiarising-yourself-with-the-night-sky books, both based on a calendrical approach, but utterly different in tone and detail. The Skywatcher's Year is effectively a collection of weekly essays that originally were syndicated in the media in the USA. In fact, each week's feature is an article not too different in approach from *Gnomon*'s quarterly "Sky Diary!, telling the reader about particular aspects of the sky most pertinent to the date in question, and using these as a launch pad for anecdotes and descriptions of particular aspects of astronomy.

A North American bias is in evidence in both language (the Moon's shadow "trends" from west to east across the Earth during a solar eclipse), and in practical detail as, for example, the description of Scorpius as its tail clears the horizon and its various names by the native American Indians (although the Sioux called it "the Plough" because it looked to them like the two-man, double-handled wooden hook that they used for cultivation, but that was not mentioned). The Plow (*sic*) "or 'Plough' to match the proper English spelling" is called the Big Dipper, for preference (and one must admit it's a better ladle than oxen plough!). The mythologies and historical associations of the different constellations are given (sometimes at too great a length, and sometimes at odds with the most popular versions - but who cares?) as well as the interesting objects for unaided eye, binocular and telescopic observation.

There are many minor discrepancies and some errors (the description of the tides, in common with so many publications, is in error, in fact in this case self-contradictory) but there is much to enjoy. It provides a novel way of dipping into an astronomy book ("I wonder what it is about this week?") and the appendices provide rough and ready methods of finding out where the solar system bodies will be, eclipsing each other and so on, for the next quarter-century.

The popular Ridpath/Tirion book is a condensation of several of these authors' previous efforts, and the fifth edition of this one. A sort of monthly *Nortons Star Atlas*, it is very well illustrated with Tirion's superb graphics, and packed with detail. The listings of planetary and Sun/Moon events are restricted to 2004. So guess when the next edition will be coming out!

*Seven wonders of the Cosmos* Jayant Vishnu Narlikar. Cambridge University Press. 324pp. ISBN 0 521 63898 4 (paperback) £12.95. Which of the millions of wonders of the Universe would you pick to match this title? (An essay topic for your students?) Professor Narlikar in fact uses the framework to cover quite a lot of astronomy, each of his seven wonders being an area - such as the evolution of stars, exploding stars, the force of gravity, the effects of scale, universal expansion and so on. Add some whimsical challenges - such as how can you see the Sun rise in the west? - and you have an intriguing book. It does get a bit tough from time to time, but the wide range of topics in a relatively small book is impressive - from the work of Galileo to special and general relativity. Have I deterred you, dear Reader? Professor Narlikar will not, I am sure.

*Destiny or Chance: our Solar System and its place in the Cosmos.* Stuart Ross Taylor. Cambridge University Press. 229pp. ISBN 0 521 48178 3 (hardback) £17.95.
The author, who is an Emeritus Professor at the Australian National University, has tackled many of the most fundamental philosophical challenges of astronomy and cosmology in this little book and is an absorbing read. He highlights the many anomalies that grow at least as fast as the new discoveries that arise from novel techniques - such as the HST - and would help inspire any reader to compare the universes of the chemist, physicist, biologist, and theologian.

The outstanding problems are many, and are often seemingly intractable. Other authors have often swept them under the carpet. Why are the planets and their satellites so different from one another? Does life control the environment, or does the environment control life? Where did the Moon, or the Earth-Moon come from? At the same time, do such questions matter, other than to demonstrate the extreme range of diversity of the planets in our own Solar System and hence the irrelevance of such questions to the evolution of planets elsewhere in the Universe? His most important conclusion is inevitably most controversial. We are probably alone in the universe as far as conscious intelligence is concerned, he thinks, In view of this, why has our species failed to overcome its serious intellectual limitations manifest in its failure to adapt quickly enough to the changes that it brings about?

*The 20-cm Schmidt-Cassegrain Telescope: a Practical Observing Guide*
Peter L. Manly. Cambridge University Press. 265pp. ISBN 0 521 43360 6 (paperback) £11.95.
This is the paperback version of the hardback published in 1994 and while specifically aimed at what the author describes as the most popular amateur astronomical telescope in the world, most of the material is suitable for any telescope user. "Practical" books are not so easy to find as Gee Whiz books, full of HST photographs and so on, so an edition at a more welcome price is welcome.

A few nasty typographical errors, spurious capital letters, some illustrations revised and improved, and several other production shortcomings ought to have been corrected over the six years since they first appeared. The author makes many of the common errors such as criticising the Plough (or Big Dipper, of which I heartily approve) for not looking like a Great Bear, when of course it is *not* the Great Bear, merely a small part of it. He has a penchant for footnotes which are often diversions from his practical topics. Much of his most practical topics are confined to the extensive Appendices, where they should have been in chapters of their own (e.g. dealing with vibration, cleaning, collimation and so on. In fact, the book should have had a thorough sub-edit before republishing.

But, having said that, the practical advice and information in this book makes it well worthwhile.

**Richard Knox**

# Curriculum Corner

## Let's think about sunshine.

By the time you read this article, this year's total solar eclipse will be over. But let's not forget the Sun now! Our nearest star is the source of almost all our energy. It is so important to life on Earth that it is raised to the status of a god in some cultures.

*Why can we see things?*

Almost everything we see we can see is because we are looking at the Sun's light. The Sun's rays travel 150,000,000km through space and land on the Earth. Some of the Sun's energy is absorbed by objects on Earth and they warm up. The Earth itself keeps a steady temperature due to this energy, some of which is reflected, and some re-radiated into space. White and shiny objects reflect a lot of light. Dull dark objects reflect only a little. So the next time you see anything, just remember that the light you see is likely to be from the Sun. Can you name something which we can see but whose light doesn't come from the Sun, or from electric or gas light? (which are also mostly power from the Sun. What energy do we use that does not come from the Sun?)

*Invisible light.*

The light from the Sun is yellow/white. A glass prism or water drops in a rainbow can be used to break up this sunlight into a number of colours. The colours form what we call the visible spectrum. But did you know that the Sun also sends us invisible light? Some light from the Sun is so energetic that we need to protect ourselves from it - in the spectrum of light it lies beyond the violet colours - it is called ultraviolet (UV) radiation. UV radiation can burn our skin red or tan it brown.

We need to protect ourselves from too much UV radiation by using a sun block cream or a hat, because UV energy can cause skin cancer. Fortunately, the atmosphere around the Earth forms a protective barrier which absorbs much of the dangerous UV radiation, but if this protective layer were to disappear then we would be in deep trouble on Earth due to the increase in UV radiation. Find out about the Ozone Layer.

At the other end of the Sun's spectrum is less energetic radiation. Some is just beyond the red light in the spectrum and is called infrared (IR) radiation. This can be felt on our skin. it makes us feel warm and is not very dangerous unless you look directly at the Sun. Even less energetic are radio waves from the Sun. These are the least energetic rays in the Sun's spectrum and you need a specially tuned radio and aerial to detect them.

*Energy in the Sun's light.*

The radiation from the Sun is energetic. This means that it can do things when it lands on Earth such as help trees grow or melt tar on the road. This energy comes from a process deep in the centre of the Sun called nuclear fusion, in which hydrogen gas is converted into radiation. Every second about 4 million tonnes of hydrogen are converted, deep inside the Sun. This energy eventually (after about a million years) reaches the visible surface of the Sun, fortunately greatly reduced in intensity, and some spreads out in all directions into space.

A small proportion of solar energy lands on the planets. On a sunny day about 1000J of the Sun's energy will land on a square metre of the Earth's surface each second. As well as helping plants to grow and keeping the land and sea warm, this energy can be used to power solar cells in watches, calculators and even in solar power stations. Each year millions of people travel hundreds of miles to places where the Sun's energy is strongest. It certainly has a positive effect on people's lives.

Here are some interesting number-crunching tasks for you. If each leaf of a tree has a surface area of about $^1/_{100}$ of a square metre, how much energy lands on a leaf every second on a sunny day, and how much on all the leaves of a tree added together? How much energy will land each second on the solar cell of a solar powered calculator on a sunny day?

*The sunshine time delay.*

The Sun's energy we enjoy today is about a million years old, due to the time it takes to diffuse through the huge sphere of the Sun from where it is produced, in the centre. The light that you see is also "old". It is eight minutes old in fact. This is because the light has to travel the enormous distance from the Sun to the Earth. This journey, over about 150 million km, takes the light about eight minutes even though, at the speed of the light (about 300 million m/s) it is going as fast as anything can possibly go! . This just goes to show how far away the Sun is. We call this distance eight light minutes. The Moon is about one light second away. Can you explain what this means?

If we could follow a ray of sunlight all the way to the next nearest star it would take it just over four years. The nearest star beyond our Sun is called Proxima Centauri and it is about 4.2 light years away. Some stars which you will see tonight might be over 500 light years away. When you next look up into the night sky spare a thought for the sunlight which has been travelling for hundreds of years just for you to capture it with your eye. And see this issue's "Sky Diary" to learn where you can find the Andromeda Galaxy that we see over 2 million years after the light began its journey towards us!

*The message in the missing colours.*

The light from the Sun can be split into its separate spectrum colours using a prism. However if you were to look really closely you would be able to see that some colours are missing. You need a specially sensitive device, called a diffraction grating, to do this. Why are some colours missing do you think? Scientists now realise that these missing colours have been absorbed by gases during the long journey from the Sun to the Earth. Most colours were absorbed as the light was leaving the surface of the Sun itself. The light passes though cool gas in the Sun's atmosphere and the molecules and atoms in this gas select out certain colours and absorb them. It was by looking at the pattern of missing colours that scientists discovered that most of the Sun's atmosphere was made of hydrogen gas.

Finally don't forget that if you want to spend a sunny day outside start your day with an egg done sunny side up, keep track of the time using a sundial, find your way by using the position of the Sun as a compass and help keep your spirits up - just make up a happy song about sunshine and remember to "just direct your feet to the sunny side of the street."

**Bob Kibble.**

# The Things People Ask!

**What's the name of the second nearest star, considering that the Sun is the nearest?** *Diogo Miranda dimiranda@ip.pt (School Pupil from Portugal)*

Query can answer this frequently-asked one using highly accurate data from the Hipparcos satellite. You can learn more about Hipparcos and its mission to measure the motions and positions of stars with high accuracy by visiting the website:

http://astro.estec.esa.nl/Hipparcos/siteguide.html

The Sun, as you rightly say, is the nearest star - it is our very own star. The next nearest star is a faint red dwarf called Proxima Centauri, an 11th magnitude object in the southern sky. The distance to Proxima, according to the Hipparcos parallax measurements, is 4.22 light years.

About 2° from Proxima is the bright double star Alpha Centauri (the third or fourth brightest star in the night sky), which is also called Rigil Kent. This consists of two stars, one very similar to the Sun, and a somewhat fainter and cooler companion, orbiting around each other with a period of 79.92 years. The pair of stars making up Alpha Centauri lies at a distance of 4.40 light years.

Some astronomers think that Proxima is not actually orbiting around Alpha, because, although Proxima and Alpha are moving through space in nearly the same direction and with nearly the same speed, and lie quite close to one another, the speeds and directions are sufficiently different that we may simply be seeing a close passage of one star by the other, rather than an orbit. They probably belong to a group of stars all moving in the same direction in space. This has been established by careful study of catalogues of stars. - *Query*

**I am trying to track down the exact wording and provenance of half remembered quote: "Of meridians and parallels man has made a net and, casting this net upon the heavens, made them his own".**

*Over a year ago (1.4.98) Mr Bailey submitted this, our most elusive question so far!*

Query has been thumbing through an entirely unrelated bit of literature and came across almost exactly the same quote. This is likely to be the source:

"Man hath weaved out a net, and this net throwne upon the Heavens, and now they are his own." John Donne

The source doesn't say where John Donne wrote this, but I think this ought to narrow it down enough for you to be getting on with. I haven't got Donne's works available though I may have selected works in an anthology at home. - *Query*

**I have heard that the planets of the solar system are going to have a special alignment during the eclipse. Is that true?**

*Fatima Masot f.masot@ee.leeds.ac.uk*

I have not heard of any special alignment of the planets during the August 11th eclipse. There has been some publicity about a supposed alignment of planets in May of 2000, but in fact all this means is that the other planets will nearly all be in the evening sky as seen from Earth. From time to time such chance optical arrangements occur and they have no physical implications or importance. - *Query* (Hey! What about the end of the World? Again? - Ed.)

**Consider a star such as our Sun. I understand its future fate is to become a red giant and then a white dwarf. But what happens after that?**

*Steve Ostler, amateur astronomer (intermediate) vytek@globalnet.co.uk*

It is true that astronomers predict the future evolution of the Sun will be that it will swell up into a red giant, produce a 'planetary nebula' like the Ring Nebula in Lyra, and leave behind a hot, small, faint remnant star called a white dwarf. Many stars have gone through this evolutionary path already. We know this from the observation that white dwarfs exist, and that planetary nebulae are also observed, with giant hot stars at their cores, confirming in broad outline the theories that predict the fate of the Sun itself.

The remnant white dwarf can be of any mass as long as it is not greater than the so-called Chandrasekhar limit, 1.4 solar masses, which is the maximum amount of matter possible in a degenerate star. Anything more massive than this would shrink to a very small size until it became a neutron star. Ordinary stars are supported against gravity by the pressure of the hot gas inside the star. But a white dwarf is supported by the pressure of degenerate electrons, that is, electrons that are attempting to share the same properties of position and velocity. Wolfgang Pauli showed many years ago that no more than two electrons can share the same state, so when a gas becomes very dense and sharing is no longer possible this creates 'exclusion' pressure as the electrons resist being pressed together. This pressure is what keeps the star from collapsing completely; if it somehow acquires more mass than the limit, it will undergo a further collapse.

The compositions of white dwarf stars are usually helium (He) (most of them), but OHeMg white dwarfs are also believed to exist, and the current model of Type Ia supernovae require C white dwarfs to be formed in binary stars. The composition will depend on the stage of evolution of the red giant precursor before the ejection of the outer shells. Certainly their cores cannot be composed of any element as heavy as iron (Fe). He white dwarfs are more common simply because the lower mass stars that produce them are more numerous.

When white dwarfs form, they have high surface temperatures; after all, they are remnant cores of stars. Initial cooling is very rapid, but because of the small surface area and high thermal energy content (it is high because those electrons are moving around at high velocities, as are the nuclei) the rate of cooling slows rapidly. The main way it can lose heat is through radiation from its non-degenerate but very small surface; other mechanisms involve emitting neutrinos, or gravitational shrinking of the surface layers.

As white dwarfs radiate away their thermal energy, they

### Ask an Astronomer

"The Things People Ask!" is selected from the many questions received, and answers given by the Association of Astronomy Education's "Ask and Astronomer" Service conducted by Dr. Mike Dworetsky, University College, London. The service is available to members of the AAE by email: *query@ulo.ucl.ac.uk*, or via the AAE home page at: http://www.star.ucl.ac.uk/~aae/aaehomp.htm.

slowly cool; the calculated time for a typical white dwarf to cool down to a surface temperature about 4000K is around 10 billion years (the same order of magnitude as the current age of the Universe). As it cools, the time scale for further cooling stretches out, so it is difficult to predict how long it would take until the surface temperature might come down to, say, 300K, roughly the temperature of a pleasant summer's day on Earth. But the answer is probably in the region of 100 billion years or more. Cooling to lower temperatures would take much longer.

Since white dwarfs have some compositional layering near their surfaces, the interior of a white dwarf will probably always retain the same layers, with a fairly uniform core. The interior will retain its electron degeneracy for ever (I think!), but the surface is not degenerate and could conceivably go through phase transitions from gas to liquid to solid, or even crystallise. The surface gravity of a white dwarf is immensely strong, typically 100,000 to 1,000,000 times that on the Earth, so it is doubtful whether mountains or features could exist; no normal mineral could withstand the forces, and if a mountain like Everest formed it would be instantly crushed flat. Perhaps some hills could form, a few micrometers high!

As to what colour the reflected light from such a 'cinder' would be, this is anyone's guess. Colours of solar system bodies are due to chemical composition, and the surface layers of white dwarfs are very varied in composition. Some of them have carbon spectra, and a possible guess is that these will look very dark. But others may have surface largely of solid hydrogen, which could look blue or white in reflected light. No one really knows.- *Query*

*Just a word of thanks to all of you at the AAE Query account, and in particular Dr Mike Dworetsky for so fully answering my question (please pass this on to him). The best things in life are indeed free. With my curiosity satisfied, I now feel much better, even if the knowledge gained won't be really useful until another 100 billion years have elapsed! Thanks again. - Steve Ostler*

**Mike Dworetsky**

# Daytime Astronomy - Using Your Shadow to Find Polaris

It should first be explained to the students that at true (local) solar noon all shadows point due north. This can be observed on any day with sunshine, and the students can practice finding north a few times, marking the north with a string or stick. At true solar noon get the students to stand outside with their backs to the Sun and hence facing their shadows, and north.

First you need to find south. Practically, you could use a shadow stick. Find the shortest shadow from a vertical gnomon, or, better still, bisect the angle between two long shadows of the same length plotted when the Sun was low in the morning and the evening). Or you can work out the time of true solar noon. To calculate true solar noon you need to know the longitudinal difference between your location and the central meridian of your time zone. Your local solar time, true or mean, (or sidereal time, come to that) will be 4 minutes fast for every degree east of that meridian, or slow for every degree west.

Next, you need to know that value of the equation of time for the date in question. This can be obtained from any good astronomy book (e.g.. Norton's Star Atlas) or an almanac. Often, an almanac, such as the BAA Handbook, will give the Sun's transit times directly, which need to be adjusted only for longitude. This allows you to correct for the gains and losses in time of the true Sun compared with the Mean Sun due to the inclination of the Equator to the Ecliptic, and due to the variation's in the Sun's ecliptic longitude following Kepler's Second Law. As a last resort, you can arrange for setting things up on one of these dates (or a few days either side) when the equation of time is zero: April 12, June 12, September 1, or December 25 (the latter is not a good choice as concentration can be lacking!).

Work out the clock time for solar noon for a date over the weekend and get the students to mark a line from their heels to their head with a string or stick at home. So that they have set out on the ground at their home, a north/south line. The students must stand astride their line just after dusk, facing north. The student must then make a circle with their hands round the eyes and nose by touching the tips of their thumbs and middle fingers together. Standing upright, the Plough and Cassiopeia will be inside the circle and Polaris in the centre. All the stars inside the circle are circumpolar around the North Celestial Pole.

**Eric Jackson and Richard Knox**

# Sky Diary Autumn 1999

The main chart shows the southern part of the sky at midnight on November 15 from a position in mid-Britain.

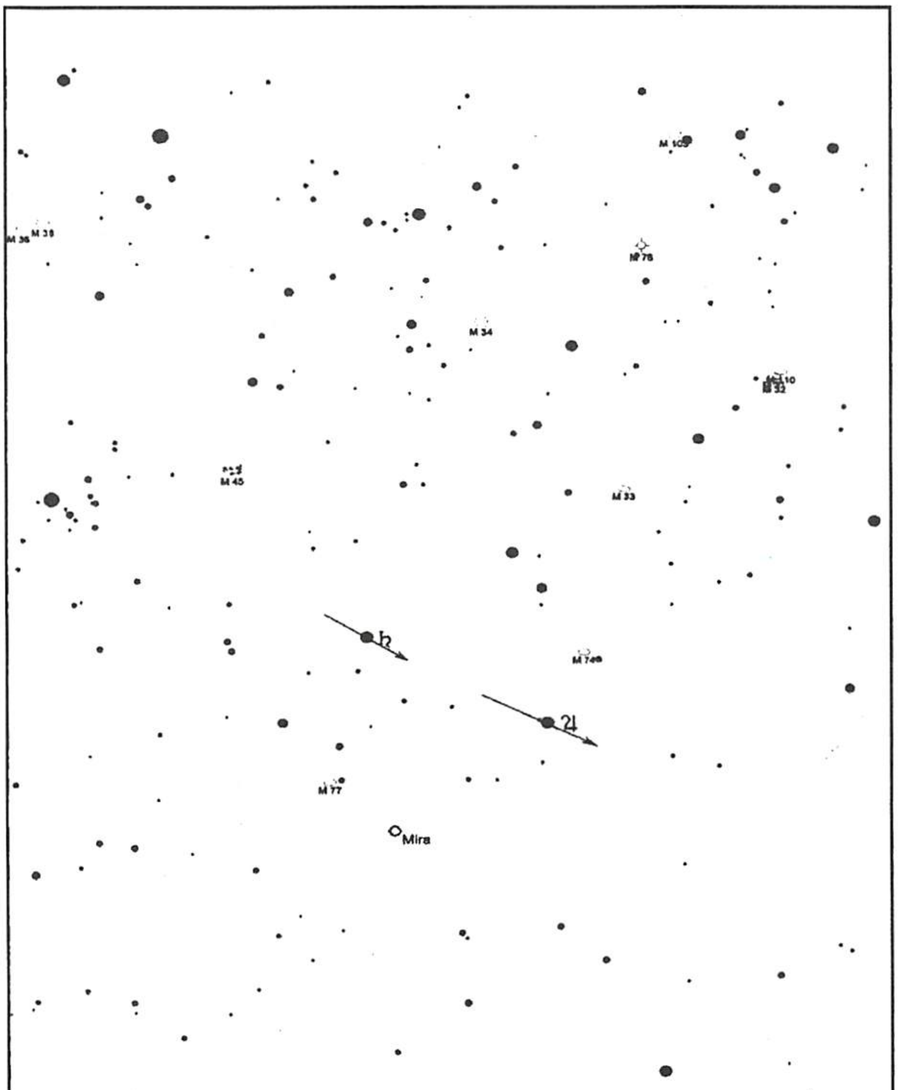
In the last "Diary" we looked at the two planets Uranus and Neptune in Capricornus (where they still are - see below) and this quarter's evening sky will be dominated by two more, Jupiter and Saturn in Aries. Jupiter will continue its pursuit of its neighbour and will display a retrograde motion throughout the period. The two planets' positions are shown for the November 15 date, with arrows indicating their motion from October 1 to December 31. For the date shown, the famous long-period variable giant star Mira is due to be close to its maximum magnitude. Since it spends most of its time too faint to be seen with the unaided eye, this will be a good opportunity to try and spot it. The two planets will help, since they form an approximate equilateral triangle with the star. The southern point of the triangle will be Mira, which is shown on the chart with an open circle, since its maximum magnitude at this time remains to be seen. Mira is also situated in a trail of stars that runs between the point of the V of Taurus' head and the brightest star of Cetus, beta, which is in the lower right corner of the chart. To the east of Mira, the fainter stars alpha and gamma form part of that straggling line. Mira is about 6° south-west of the Messier object M77, a Seyfert galaxy of magnitude 8.9 (described by O'Meara - see last issue - as having a "bright" nucleus looking like a 10th magnitude star.)

The chart shows many other Messier objects, including the Andromeda galaxy and its satellites (M31 plus M32 and M110) near the western edge of the chart above the diagonal line of stars in Andromeda which point to Perseus (the constellation in the middle of the top of the chart). Another of the so-called "Local Group" galaxies, M33, can be found at almost the same angular distance south-east of the star Beta Andromedae from which the Great Galaxy is north-west, so forming an almost straight line through the galaxies and the star. Large and bright (according to some observers, but some find it difficult) it can be spotted with the naked eye in the best conditions.

Also shown are two of the delightful star clusters in Auriga, M36 and M38 (top left), and the most famous cluster of all, the Pleiades (M45) to the north west of Taurus' head. If you have never studies the Pleiades in binoculars, it's time you did!

**Approx. rising and setting times**

| | Oct. 15 | | Nov. 15 | | Dec. 15 | |
|---|---|---|---|---|---|---|
| | Rise | Set | Rise | Set | Rise | Set |
| Sun | 06h 42m | 17h 34m | 07h 33m | 16h 39m | 08h 13m | 16h 20m |
| Mercury | 08h 59m | 18h 03m | 07h 43m | 16h 14m | 06h 44m | 15h 24m |
| Venus | 02h 36m | 15h 58m | 03h 15m | 15h 10m | 04h 24m | 14h 25m |
| Mars | 12h 53m | 20h 31m | 12h 19m | 20h 22m | 11h 22m | 20h 33m |
| Jupiter | 17h 54m | 07h 40m | 15h 40m | 05h 12m | 13h 41m | 03h 08m |
| Saturn | 18h 33m | 08h 55m | 16h 21m | 06h 36m | 14h 22m | 04h 32m |
| Uranus | 15h 18m | 00h 27m | 13h 12m | 22h 22m | 11h 16m | 20h 30m |
| Neptune | 14h 38m | 23h 25m | 12h 37m | 21h 25m | 10h 41m | 19h 31m |




*Looking south at midnight, mid-November 1999*

**Moon phases for the fourth quarter of 1999**

| Month | New Moon | First Quarter | Full Moon | Last Quarter |
|---|---|---|---|---|
| October | 9 | 17 | 24 | 31 |
| November | 7 | 16 | 23 | 29 |
| December | 7 | 15 | 22 | 29 |

The Pleiades were the daughters of Atlas (who, incidentally, is also in the cluster!) and were the objects of Orion's unrequited love. The Great Hunter still pursues them across the sky. Often called the Seven Sisters, I once challenged a young man for whom I was conducting a quick tour of the late autumn sky, but who was not especially interested in astronomy, to count the Pleiades. He told me he could see eight or nine. I used to be able to count seven when I was his age, and thought that was pretty good! So I asked him to sketch the group that he could see, and the result showed clearly that he was not boasting. It struck me as an excellent experiment for a class of students who have had at least a little practice in sketching star groupings, as long as they have not studied the group through binoculars.

So if your view of the evening night sky is restricted to the area shown in this quarter's chart, you have plenty to keep you busy.

Events during the quarter include the increasing dominance of Venus in the morning sky. The planet's increasing western elongation will provide a perfect opportunity to watch it right through sunrise into the daytime sky. Jupiter reaches opposition on October 23 and will be closer to Earth at 3.963a.u. (and hence largest angular size) than it will be for the following eleven years, because it was at perihelion in May.

There are some interesting conjunctions and occultations. A close approaches of Mars to Uranus (also near Theta Capricorni which is only 0.6° to the north of Uranus - see last issue) on December 9.

The Moon has an interesting time too. It passes very close to Neptune (there is an occultation to be seen in Hawaii) on October 17; then close to Uranus (occulting it as seen from most of the USA) on October 18; going through the V of Taurus at dawn on October 26; passing close to Jupiter and Saturn on consecutive days each month (October 24 & 25, November 20 & 21, and December 17 & 18); and occulting Mars soon after sunset on December 12, as seen from the UK (but see "Spode Defined" page 3).

Meteor fans are getting ready for what could be a "storm" of Leonids on the night of November 17-18, anticipated to peak at about 02.00h, but which might be worth looking at any time from 15th - 20th. Don't miss it! (see also "Spode Defined").

**Richard Knox**