The Astronomical Society of Edinburgh

Journal 39 - Summer 1999

Members' Barbecue at Earlyburn

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From the President

It has been quite an eventful period since the last Journal was issued.

As mentioned in the last annual report there is likely to be extensive refurbishment work at the observatory and it is highly unlikely that we will be able to move the library books back to the Playfair Building this year. Our Secretary, Graham Rule continues to represent the Society's interests in attending the Calton Hill Advisory Group meetings and we will keep you informed of the continuing developments as they arise.

Sadly in April of this year David Todd died of a long-standing illness. David worked tirelessly behind the scenes as Secretary and Treasurer of the ASE Trustees. It is chiefly thanks to his careful management of the Trust's assets that we have been able to maintain the current membership subscription fee without increase. An obituary for David Todd appears in this Journal.

The astronomical event of this year will surely be the spectacle of a total Solar Eclipse on 11th August. For those not venturing to Cornwall or elsewhere to view the spectacle of the total eclipse the Society will open the City Observatory to the public on the day to allow people to view the partial eclipse in safety. It is hoped to use this event to increase public awareness of astronomy and the Society's activities.

Last year also saw the opening of the UK Astronomy Technology Centre at the Royal Observatory Edinburgh. We have always been fortunate as an amateur astronomy society in having the ROE on our doorstep to provide, amongst other things, many of the speakers for Friday night meetings. As Calton Hill was formerly the site of the Royal Observatory before it moved to Blackford Hill it would be nice to strengthen the links still further between the two observatories. To this end it is hoped to meet with representatives from the ROE in the near future.

Last month, the lease for the use of Earlyburn, the Society's dark sky observing site was finally agreed and signed. To celebrate this event we decided to hold this year's wine and cheese at Earlyburn and have a barbecue. Around forty members were able to attend what turned out to be a very successful evening. The Society is indebted to the National Environmental Research Centre who have been kind enough to allow us to use the grounds. On an individual basis special thanks must go to Charlie Gleed, Jim Douglas and Kenny Laidlaw who over several months have spent considerable time and effort in constructing the much-needed shelter for observers who venture to this remote spot.

Last year Jamie Shepherd decided to stand down from the post of Observatory Director after a period of office lasting fifteen years. Jamie's particularly valuable contribution to amateur astronomy in the Society is appreciated by all. The work formerly done by the Director has been shared by the Observatory Management Committee (made up of the President, Secretary and Treasurer).

At the last AGM the following new people have been welcomed onto the Council: Dr George Grant, Adrian Weatherhead, Ray Fenhoulet. One of the main discussions at the AGM was the feasibility of restructuring the Society as a company limited by guarantee. Those present generally approved of the rationale behind this and the Council intends to present full proposals to the membership in the autumn.

The Scottish Astronomy Weekend this year will be in Dundee from the 10th to 12th September. This is a must for anyone wanting to seize the chance to talk and do astronomy over a weekend with other fellow astronomers from all over Scotland. Thanks once again to Dave Gavine for organising this event on behalf of the Scottish Astronomers' Group.

Finally I would like to remind people that this year's Members Night is fast approaching and will take place on the 6th August. If you wish to participate by giving a short talk on an astronomical subject of your choice please get in touch with any Council member.

Alan Ellis

OBITUARY - David Charles Todd AIB

We are very sorry to report the death of Mr Todd in Carlisle on April 21. He was born in Carlisle in 1923 but regarded himself as a Scotsman and always wore the kilt. He started work at the Westminster Bank but in 1942 he was in the branch in Liverpool near the docks when it was hit by an enemy bomb. He was trapped in the rubble for three days before being rescued, and as a result suffered lung damage which plagued him on and off. Sometimes he was seriously ill but his fighting spirit always brought him back to full vigour. However, he was in declining health in his latter years. He came to Edinburgh and joined our Society, but left for Carlisle some years ago to be near his ailing mother. He was a member of the Council, Vice-President in 1982-83 but declined the Presidency. He acted as Secretary and Treasurer of the ASE Trustees who have looked after the substantial legacy the Society received from John Henry Lorimer in 1938, and as the Auditor of our accounts, declining to take any fees or expenses for both duties. We are very much indebted to him and regret his passing.

Observations

Meteors: The *Leonids* caught everyone by surprise, giving not a storm but a very vigorous display on the night before they were tentatively predicted. In the early hours of Nov 17 (1998) Dave Gavine looked out in the hope of catching a few "casual" meteors and saw the event at its height in 2½ hours (0115-0400 with a 15 minute tea & warming-up break) he saw 194 Leonids and 4 Sporadics. All the Leonids left trains, many were very brilliant. One amazing fireball at 0215 was about -10 (nearly as bright as the Moon), it was also seen by Lorna and Douglas McCalman who clocked up over 60 meteors, and it left a train in Gemini lasting 16 minutes, twisting in upper-air winds. Many meteors were also seen by Charlie Gleed. Dave photographed 22 meteors, 7 of them on one frame. The following night was overcast, but on 18/19 Dave saw 3 Leonids and 3 Sporadics in 1 hour, none of them bright. Spare a thought for poor Jamie Shepherd who went to Australia in anticipation of the expected huge event in the eastern hemisphere, and saw only a handful. Watch out for a possible repeat this November and keep reading the literature.

Dave Gavine saw 51 Geminids over the 3 nights 12-15 December but in rather poor skies.

Aurora: Only one major display despite the rising solar activity. Jan 13/14, an intense homogeneous arc visible when the clouds cleared at 2110, then bright green and red rays spread along it and filled most of the northern sky. It broke up into flaming patches and ray bundles but was gone by midnight. Ron Livesey followed the activity on his magnetometer, Dave Gavine took photographs, and it was also observed by Lorna McCalman and Charlie Gleed.

Charlie took photos of the close approaches of the planets Mercury, Venus, Jupiter and the Moon in February but the night of the very close conjunction of Venus and Jupiter was overcast. He is fitting a 60mm guide scope to his 8-in Meade Schmidt-Cassegrain.

Ron Livesey continues to monitor the magnetic field and the sunspot numbers. He, Dave and Lorna are also involved in variable star programmes.

Dave saw Noctilucent Cloud on June 19/20, 20/21, 23/24 and July 4/5 but they were faint and summer skies have been very poor so far.

Dave Gavine

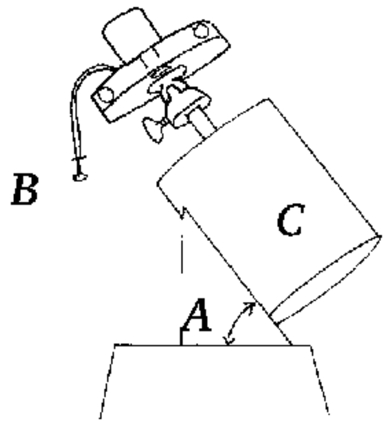
Popular Geology Class

Dave Gavine will be teaching an evening class in Popular Geology commencing on Monday 11th October. Each of the 8 classes are on Monday from 6:30pm until 9pm at the Jewel & Esk Valley College in Milton Road. For further details please contact Dave (0313 657 2338) or the college (661 1010). The fee for the class will be £38 (although there may be concessions available). Please note that enrollment **before** the first meeting of the class is encouraged.

Cheap and Easy Astrophotography

There are several ways for the amateur astronomer to photograph constellations or star-fields, to record comets, meteors, variable stars or just for pleasure. For meteors, normally we just mount the camera on a tripod, point it at the sky, set it at about f2.8 and open the shutter for about 10 minutes. The result is, of course, trailed stars, but it is the meteors which matter. If you guide the camera correctly you will get point-image stars. How is this done? The camera has to move at the "sidereal" rate, i.e. at the true rate of the Earth's rotation with respect to the stars. One sidereal day is 23h 56m 4s.

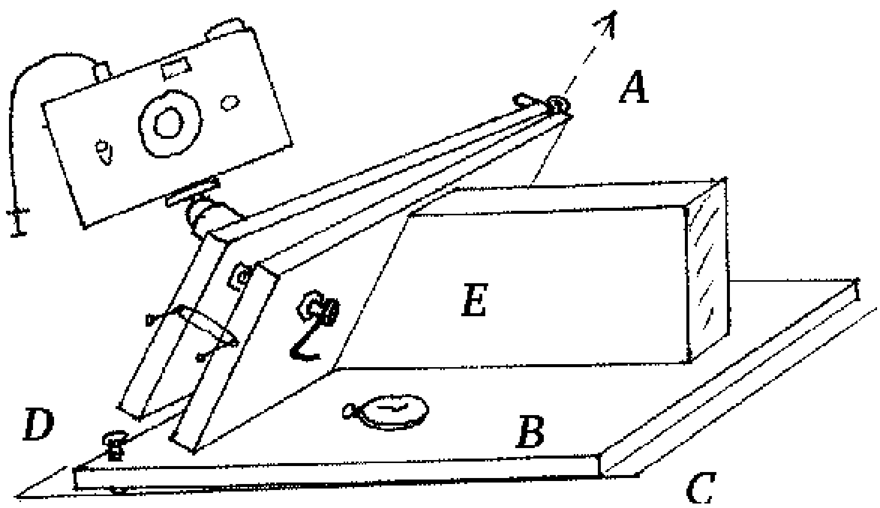
One way is to mount the camera "piggy-back" on a telescope with an accurate clock drive, preferably one with controls in RA and Dec. The telescope itself is used as the guider, and an out-of-focus star is kept centrally on cross-hairs in the eyepiece. A counterweight is usually necessary as the camera upsets the balance of the telescope tube. You can get an equatorial head which can carry one or more cameras and drive them at sidereal rate, it even has a sighting device through the polar axis for aligning it on the Pole Star, and it can be driven off a car battery. Jamie Shepherd and John Reid have these, and their wonderful pictures of Comets Hyakutake and Hale-Bopp show what can be done in the hands of real experts.



A: Angle set at observer's latitude; B: Cable release; C: Clock barrel

Fig 1: The Clockwork "Leerie" with camera pointing near the celestial pole

Some of the Oldies among us remember when the lamplighter or "Leerie" used to come round the streets at dusk, lighting up the gas lamps with a puff of flame from the top of his magic pole (we, the bairns, followed him, always hoping for a "shottie" but never got one lest we broke the fragile mantle). Then in the Fifties wee clockwork Leeries were installed in the lamps. They switched the gas on and off and ignited it, like modern electric timers. When they, in turn, were declared redundant in the Sixties as the streets went all electric, amateur astronomers and model makers were able to pick them up very cheaply, or even free, from the lighting depots. I've still got mine! The Leerie is mounted on a simple stand (fig. 1) so that its spindle, which rotates once a day, is pointing at the celestial pole, and upon which spindle is clamped some Meccano or other device for holding a camera. It gives pleasing star-field results with exposures of up to 5 minutes, but any longer and you will get slightly oval stars because the clock is geared to solar, not sidereal time. Also it is quite hard to align accurately on the Pole. Its advantage is that you can leave it running and do something else.

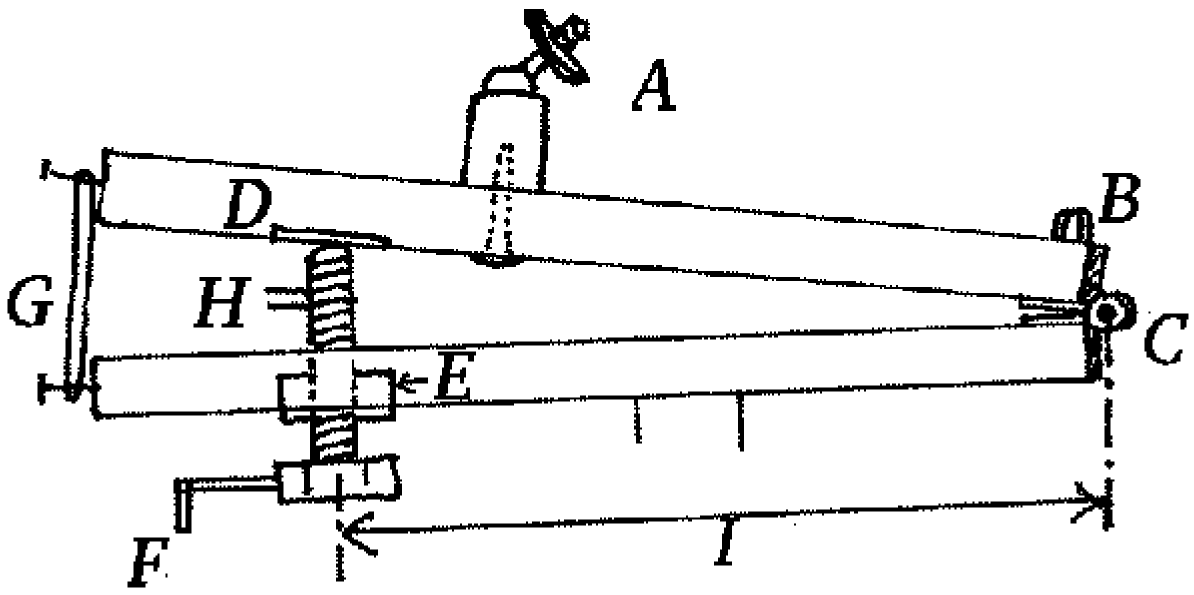


A: Hinge-line points to Pole Star; B: Base board;
C: Stable platform or table; D: Levelling screw; E: Stabilising block

Fig 2: The Haig Mount

Now we come to the Scotch Mount or Haig Mount in honour of the man who championed it and other simple astronomical devices, Mr George Haig, who is now retired from his lecturing post in Physics at Paisley Technical College (now University) where he installed his own home-made planetarium. This consists of two panels of wood hinged together at one end and mounted firmly on a wooden block so that the hinge-line is aligned on the Pole Star. The upper panel carries the camera, and it is made to move at the sidereal rate by turning a screw. (fig. 2).

The "magic number" for a Haig Mount is 229. That is, the distance from the centre of the hinge to the centre of the screw is 229 times the pitch of the screw. The pitch is found accurately by measuring the length of the threaded part of the bolt and dividing by the number of pitches in this length. (fig 3).



A: Ball & socket head; B: Sighting staples; C: Hinge; D: Metal plate set into wood; E: Nut set into wood of lower board; F: Handle to turn screw; G: Rubber band; H: Pitch of screw; I: Distance = 229 x pitch

Fig 3: The Haig Mount

Why 229? Let the screw turn once in one minute. This lifts the upper, camera-carrying panel by one pitch of the screw and turns it through a very small angle given by

$$\arcsin 1/229 = 0.2502°$$

Multiply this by the number of minutes in a sidereal day, 1436, and you get 359.3 degrees which is as near the full circle of the sky as you need. However, the screw is straight, not an arc of a circle, so it is best to limit your exposures to about 5 minutes because the rate of angular increase gradually changes and again you will get oval stars.

Set up the machine on a firm base, not a tripod. Mine is mounted on a wooden board with levelling screws and two white-painted staples along the hinge-line through which, with the aid of a small mirror, I line it up on the Pole Star. Then it is secured by elasticated straps. The camera, fitted with a lens-hood and a cable-release, is set on the desired star-field. Cover the lens with a black hat, open the shutter, start the exposure and carefully turn the screw, with the aid of a handle, synchronously with the second hand of a watch. Give it about 4 or 5 minutes then cover the lens with the hat and close the shutter. This reduces tremor.

It is best to use a 50 mm or a wide-angle lens as a telephoto will show up the small errors in the system. Use f2.8 or even f4 because with wider apertures you may get coma at the edges of the field and pick up the sodium glow if, like me, you live in or near a big town. A Neodymium filter cuts off the sodium glare from low-pressure lamps but is ineffective with the high-pressure type. A pale blue filter might help as a substitute. Use transparency film such as Ektachrome 200 or 400, indeed, almost any film will give pleasing results. If you want extra accuracy in driving, don't line the machine up on the Pole Star itself but at the true Pole which is about one degree (2 moon-diameters) towards Eta UMaj. And when you begin driving have the two wooden plates as close together as possible. Tension them with a small rubber band.

There are small disadvantages. You have to stand and freeze while turning the handle. I tried using a small electric motor to turn the handle, one rated at one r.p.m., but with the cold and the torque required to drive a heavy camera it never worked properly. In Joppa I now have the misfortune to lie under a frequently-used flight path into Edinburgh Airport. Guess what happens whenever I start an exposure!

Still, I recommend the Haig Mount to all budding photographers. For further information on this and many other topics see **Astrophotography : An Introduction** by H. J. P. Arnold, (Philip's Observer's Handbook, ISBN 0-540-06086-0.)

Dave Gavine

Advertising Feature

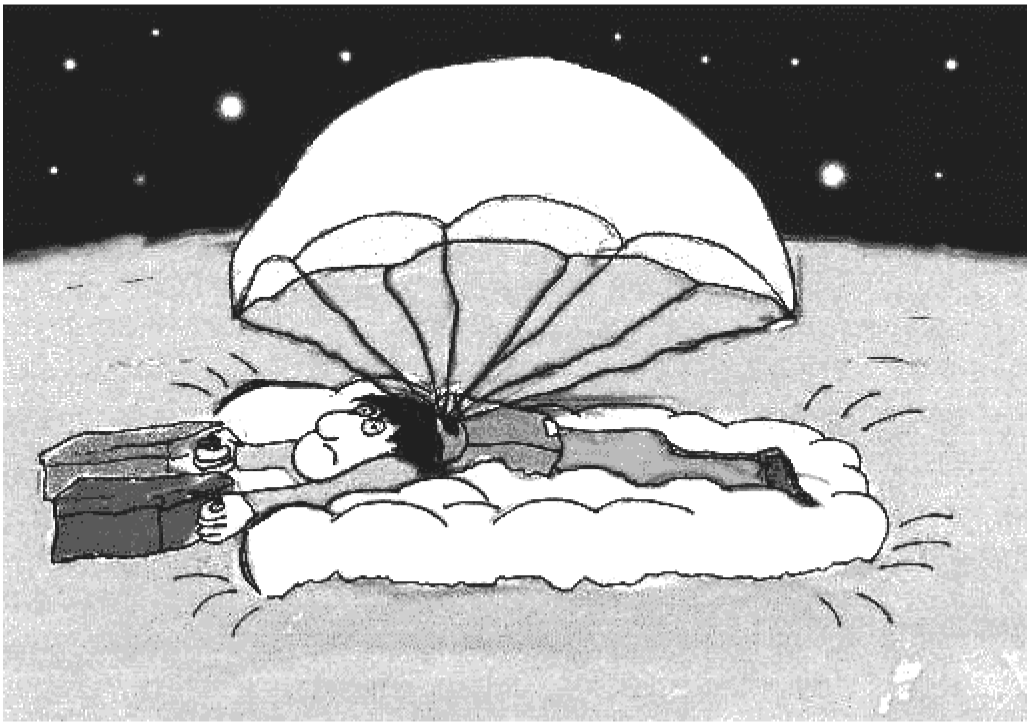
FED UP WITH EARTHLY WEATHER?
WISHING FOR A HOLIDAY WITH GUARANTEED SUN?
THEN READ ON...

With the summer holiday period almost upon us, we will all be pouring over our holiday brochures wondering where to go this year for a wee change. This travelogue, not ABTA approved, is aimed at the first holidaymakers who wish to travel to Mars, **the ultimate in adventure holidays** and describes the conditions you might expect to find when you arrive there. Unlike some other tour operators, we are 100% honest with our description of your holiday destination.

Background

Two summers ago we saw the first of the new generation of cheap and cheerful missions to Mars. Probably not since the moon landings has NASSA enjoyed such public interest and excitement in a project. Pathfinder, the landing vehicle, was dropped from orbit around Mars from a height of *9.5km* by parachute and landed with the aid of gigantic airbags to cushion the fall. Once landed, Pathfinder opened up its petal-like sides and out trundled the star of the show, Sojourner. This cute little roving buggy, looking for all the world like something you made with your Meccano set when you were 10 years old boldly set forth over the Martian terrain. Sojourner became an instant celebrity, even developing its own persona, unlike its' sleek muti-million dollar predecessors. These were the pioneers of Martian travel.

Travelling



Hang onto your luggage!

The first requirement is the necessity of a very understanding boss willing to allow you a very long holiday, at least three years should do nicely. Choice of carrier is a bit limited at present, NASSA being the only operator currently flying to Mars. Their advice to check in very early should be heeded. You do not want to miss your launch window because the next opportunity won't happen for another 26 months. The flight itself lasts for 6 to 7 months so take plenty of things with which to entertain yourself. ("War and Peace" is probably a sensible choice of reading material). Clutching your boarding pass and your supply of Duty Free, it is at this point that you must be certain that you really want to go to Mars because once there, you will have to stay for another *550* days before the appropriate launch window back, a very long stay if you don't like the place. One of the benefits of flying with NASSA does mean that you can take advantage of the new landing technique which worked *such* a treat with Pathfinder. Arrival should be fun - a cross between a bouncy castle and a huge bungee jump. But do hold onto your luggage for if you let go, it will end up on the other side of the Solar System (no change there then!). On the subject of luggage, pack every last ounce of your allowance. Once on Mars, everyone is guaranteed to feel light on their feet. For every 100lbs you pack on Earth it will weight only 38lbs on Mars so your luggage will be easy to manage.

Return Travel

Even with a super deluxe 1st class ticket, return is a sticky problem. In the 1960's, in order to prevent any chance of bacteriological contamination of the Earth , the Soviets and the Americans signed a 50 year moratorium giving each other the right to *shoot down* any returning spacecraft from Mars. This is something we recommend you do not mention to your Insurance Company when taking out your travel insurance. At present we are trying to negotiate a lease for the soon-to-be defunct space station "MIR" with the intention of applying for planning permission to turn it into a quarantine facility for holidaymakers, their luggage and their red holiday rock. Here they can be screened for viruses and any other stowaway lowlife forms.

Arrival

On Mars, surface transport is pretty thin on the ground. In fact, Sojourner is the only wheeled vehicle on the entire planet and it's not speedy. The top speed is around 2 feet per minute however as there is nowhere to which to rush, this is more than adequate, but a spare set of batteries for Sojourner is a wise move because there is no AA homestart.

Accommodation is fairly basic. There are no five moon hotels as yet as Holiday Inns have not yet reached Mars, but the more people who venture there, the more standards will take off. The best accommodation at present is either a squat under Pathfinder or a do-it-yourself tent made from the landing airbags. It's not comfortable but it is a roof over your head.

The co-ordinates for Pathfinder are available, but Mars doesn't seem to have a magnetic field. Whether this is permanent or not we aren't sure, but leave your compass at home because it won't work.

Climate and Atmosphere

One of the major inconveniences of the Martian climate is the deplorable lack of air. The atmosphere is 95% CO_2 with oxygen making up only 0.13%. The atmosphere is much thinner than it is on Earth with the pressure barely 1%. So if you intend to stay longer than around 3 minutes and intend to do much breathing, you will need to take a good supply of air with you.

Mars has a tilted axis therefore it has seasons as on Earth. However, the weather is more extreme. Basically the Northern hemisphere has a more agreeable climate enjoying 174 sols of spring and summer. Today's forecast for example is a maximum daytime temp of 150°C dropping to a rather bone chilling -68°C by tonight. In the winter the temperature drops clean off the end of the thermometer, so take lots of thermal underwear. I am informed that the layered look is very fashionable in Mars this year.

Dust storms can blow up very suddenly with winds of up to 70mph, but because of the low atmospheric pressure, there is no force behind it. However you can rest assured that the sand will still find it's way into your socks! On the plus side, as with the compass, leave your umbrella at home because it hasn't rained on Mars for Aeons.

Nightlife and Eating

Everyone says that Mars is dead after 9pm, but frankly it is dead the rest of the time too, so take along someone special to while away the long nights. You will see the stars much brighter than on Earth because of the lack of Martian atmosphere.... well, dust storms allowing you will.

Basically you will have a terrible job even tying to get a decent cup of coffee, so the best advice is to pack a picnic. In fact pack around 450 picnics depending on the length of your stay. The good news is that food preservation on Mars is no problem, for example a cheese sandwich will last for several millennia, although you may want to protect it from the UV radiation.

Barbecues are out of the question because there's no oxygen to start your fire. Take your kids advice, don't eat your greens before going out in your spacesuit.

There are no Mars bars, but the low atmospheric pressure would mean that any alcohol would have quite a kick. One drink and you can't remember your name or where you live. This marks Mars out as the Iberia of the next millennium because it is so cheap to get drunk there.

Tourist Attractions

Mars has 2 moons, Phobos and Deimos. Phobos is the larger and is in a very low orbit, in fact if you are near the poles you will not see it at all. It will be eclipsed by Mars. It is an absurd lumpish coalsack measuring 13 miles x 17 miles and you could cycle around it in 2-3 hours. This is an interesting day trip, but do be careful not to fall into the rather large crater, Stickney. There won't be a problem in jumping out of the 6 mile deep crater because of the lack of gravity, so little, that there is a danger that you could jump clean off the moon and end up as the third object orbiting Mars.

Deimos is in a higher orbit and hangs around in the sky for around 60 hours at a time. It measures 10x6 miles and a good stiff walk (no bicycle hire on Deimos) should take you around it in an afternoon. Phobos is the sillier of the two. It runs backwards, rushing through its' phases as it scoots across the sky in only 4 hours. Both these clownish moons have eccentric motions, but neither will provide much light to see your way around at night and neither is likely to be conducive to romance.

No trip to Mars would be complete without a trip to Mariner Valley. It is vast and on earth would stretch from coast to coast across the USA. The valley is 2500 miles long, 150 miles wide and up to 4 miles deep in places. Also worth a visit is the Tharsis ridge, home to 4 giant volcanoes which as far as we are aware, are extinct. And what about a trip to the rock garden, home to such famous names as Scooby Doo, Barnacle Bill and Yogi?

Mars is smaller than Earth, but because it has no oceans, on Mars we have a greater scope for outdoor activities and exploration. The great outdoors is also due to the fact that there is no indoors yet on Mars.

So why go to Mars? Why not go to the Greek Islands again? Anyone who enjoys a crisp and bracing climate and picturesque boulders far from the madding crowds should look no further. Mars has something for everyone, from a switched on rock scene to miles of pristine wilderness in guaranteed sunshine for 687 days a year.

The adventure starts here. For more information on Mars, contact your nearest Astronomical Society for further details.

Happy holiday and Bon Voyage wherever you decide to go.

Adapted by Lorna McCalman from "The Traveller's Guide to Mars" by Dana Facaros, Michael Pauls; Cadogan Guides; ISBN: 1860110142

Scottish Astronomy Weekend 1999

The *Scottish Astronomy Weekend* this year will be back in Dundee by popular request, accommodation in the excellent Belmont Hall of Dundee University. It takes place on Sept 10-12 and incorporates a variety of topics, from planetary systems beyond the Solar System, meteorites, lunar soil, the Earth observed from space, and variable stars. The guest speaker is Storm Dunlop, well known to our Society as a "star" performer.

Visits to Glamis Castle and the Mills Observatory are included.

Total cost including all meals and 2 nights B&B: £105.

For further details please send an SAE to Dave Gavine, 29 Coillesdene Crescent, Edinburgh EH15 2JJ, or phone 0131 657 2338 as soon as possible.

Black Holes - Part 1 - History

This article on Black Holes is a condensed version of the talk I gave to the Society earlier this year. Most people are familiar with the term 'Black Hole' and have at least a vague idea of what they are. The very term conjures up the notion of a bottomless pit or abyss. Furthermore science fiction films on the subject such as Walt Disney's "The Black Hole" and "Event Horizon" have to a certain extent contributed popular general interest in this area.

A Black Hole is, in simple terms, just a region of space-time where the gravitational field is so strong that nothing, not even light, can escape. So what made them such a topic of interest and why all the fuss about them during the second half of this century?

What often surprises many people is that the idea of a 'Black Hole' was first contemplated more than two hundred years ago in the late 1700s.

A paper written by the Rev John Michell in 1783 was discovered in the 1970s. This is the first known discussion of the concept of a black hole. John Michell (1724-1793) was born three years before the death of Isaac Newton. He became a well-known British geologist and astronomer and was later regarded as the 'Father of Seismology' in his study of Earthquakes. He is also credited with the idea of Binary Stars, the demonstration of an inverse square law in magnetism, and was the inventor of the torsion balance before instigating the experiment, later completed by Cavendish, to weigh the Earth.

At the time the 'corpuscular' theory of light was the vogue. This regarded light as being made up of 'corpuscles' or particles similar in some respects to the modern idea of the photon. It was therefore considered a possibility that light could be affected by gravity in the same way as ordinary matter. Over one hundred years prior to this in 1676 Olaus Roemer had discovered that the speed of light was finite through observed variations in the period of Jupiter's moon Io. Observations of stellar aberration by James Bradley in 1728 produced further confirmation and a more accurate value for the speed of light of 295,000 kilometers per second compared to today's figure of 300,000 km per second. The Newtonian concept of escape velocity as being the minimum velocity needed to escape from a planet's surface to infinity was well understood. For a spherical mass M of radius R it is simply: sqrt (2GM/R) where G is the Gravitational constant. The escape velocity thus increases as the object's mass increases and also increases if the mass remains the same but the radius gets smaller.

Michell pondered a body so massive that the escape velocity at its surface was equal to the speed of light. In his 1783 paper to the Royal Society Michell wrote:

> If the semi-diameter of a sphere of the same density as the Sun in the proportion of five hundred to one, and by supposing light to be attracted by the same force in proportion to its [mass] with other bodies, all light emitted from such a body would be made to return towards it, by its own proper gravity.

In the above Michell contemplated the existence of a star 500 times the radius of the Sun and of the same density. For such an object he calculated that the gravitational field would be so strong at its surface that the escape velocity would exceed the speed of light. From this hypothetical star not even light could escape and the star would be invisible. Although he thought it unlikely, he considered the possibility that many such objects could be present in the cosmos without us being able to see them.

In 1796, thirteen years later the great French mathematician, astronomer and physicist Pierre Laplace proposed similar ideas to those of Michell in his famous paper 'Exposition du Systeme du Monde'.

In the early 1800's experiments on optical interference led to the predominance of the wave theory of light and the end of the corpuscular theory. Since light waves were thought to be unaffected by gravitation interest in the hypothetical "dark stars" ceased.

In 1905 Albert Einstein published his Special Theory of Relativity and in 1915 his General Theory of relativity. The General Theory was a new theory of gravitation and one of its fundamental predictions was the effect of gravity on light. According to the theory matter causes space-time to curve. The paths followed by light rays or matter is determined by the curvature of the space-time and allowed a modern scientific proof of Mitchell's hypothesis.

Further researchers followed on from Einstein and this will be described in Part 2.

Alan Ellis

Doing anything on August 11th?

I'm sure that I don't need to tell members that there will be a Solar Eclipse on August 11th. But what are you planning on doing then? I'm sure that some will be going off to Cornwall or further afield to the path of totality and my best wishes go with you.

But for those of us staying in Edinburgh, what plans can we make?

Weather permitting, the Observatory will be open for members of the public to see the eclipse in safety. We will have a couple of telescopes projecting the Sun's image - the only guaranteed safe way of viewing the sun, even when 80% or more is covered by the moon.

Elsewhere in this journal we have included a paper on *Eye Safety And Solar Eclipses* published by NASA. Please **do read it** and be careful whenever trying to observe the Sun. There are a lot of myths about 'safe' observing methods - many of which could result in permanently damaged eyes.

If you cannot be at the observatory on the 11th here are some methods I have used to observe the sun recently.

Projecting with a telescope

This is a matter of allowing light to pass through the telescope and on to a screen of some sort (for example a sheet of paper on a clip-board).

It is important to remember, when pointing the telescope at the Sun, that it is **not** safe to use the finder (which should have its cap on or have the front covered in some way). It is even more disastrous to look through the main telescope - you are likely to go permanently blind. Instead, stand with your back to the sun, and adjust the telescope to make it's shadow as small as possible. When it's shadow is smallest the front of the telescope will be pointing at the sun and the sun's light will be shining through it. Then you can hold your screen in place and adjust the focus to give a clear image.

Generally you will not want a very high magnification for projecting the Sun's image - chose an eyepiece which would allow you to see all of the full moon in the field of view.

If your telescope has a drive you can start it running while undriven telescopes will require constant manual adjustment. But in either case **never leave the telescope unattended** in case the focused image of the sun drifts off and burns the inside of the tube - or even worse, someone tries to look through the eyepiece.

The image from a refractor is usually directly behind the telescope and you may find it helpful to attach some sort of shade around the telescope or project into a box - to minimise the light hitting the screen that is not from the telescope.

A Newtonian reflector (or a refractor with a 90° elbow mirror) can quite easily be used to project the image to side of the telescope. Careful positioning can allow projection on to a shaded wall or in a doorway or open window.

The image projected on to a screen is quite likely to be amenable to being photographed with a simple camera with automatic exposure setting - just make sure that you are not too close to the screen for the camera's focus. Further information about photographing the eclipse is in the article *Eclipse Photography* also reproduced from the NASA Eclipse Bulletin.

Projecting from a pair of binoculars

Quite acceptable results can be achieved by projecting from one side of a pair of binoculars (cover the objective of the other side) to a screen in a box. With my 8x25 'Practica Sport' binoculars stuck through a hole cut in an old A4 paper box I can get an image about 2cm across 14cm from the eyepiece. While this is not enough to show any but the largest of sun-spots it will be easy to see the partial phases of the eclipse.

Pin-hole camera

A bit less satisfactory, but workable, method is to use the same box but with a sheet of card instead of binoculars. A single pin-hole in the card results in a 4mm diameter disk - enough to see the shape of the eclipse.

Solar eclipse viewers

There are a number of sources of cardboard specs with filters in them but it is important to remember that they must never be used if they are damaged in any way. Only use those with a "CE" mark indicating that they have been properly tested and approved.

With these you will be able to see the partial eclipse but are unlikely to see any sun-spots.

Castle Photographic, Bank Street (at the top of the Mound) have safe viewers for £1.99. The booklet *Preparing for the Solar Eclipse over Britain and Europe* by Peter Smith, ISBN 0-9535657-0-X, £2.99 contains a viewer. (I have seen this in *Waterstone's* Bookshop, at the East end of Princes Street.) I believe that that August issue of *Astronomy* has a viewer on the cover.

There may be others - but watch out for that CE mark.

Exposed film, smoked glass etc - an easy way to lose your sight

Do not look at the Sun without being sure that the 'filter' has been properly tested and approved. While some people may have been lucky enough to escape serious damage to their eyes when using makeshift 'filters' it has been just that - luck. The lens in the eye is quite capable of focusing harmful radiation on to the retina and causing permanent damage.

Pass this message on to anyone you know who might be tempted to take risks with their eyesight. Its just not worth it. Anyone wanting a look at the eclipse can use one of the safe methods outlined above, or just come and join in the fun at the Calton Hill.

Time of Eclipse

The eclipse will start (in Edinburgh) at 10:05 **BST**, will reach its maximum extent (over 80% covered by the moon) at 11:18 BST, and will end at 12:33 BST.

Anyone wanting the exact times (to 0.1 second) or for other places in Scotland (or Europe) should refer to *"Total Solar Eclipse of 1999 August 11"*, Espenak and Anderson, 1997. (Available for reference in the Society's Library or online at http://umbra.nascom.nasa.gov/eclipse/990811/rp.html)

Graham Rule

James Melvill Sees a Great Fireball

Remember Rev James Melvill *(1554-1614)* who eloquently described the total eclipse of the sun in 1598? (See ASE Journal 25, March 1991). He saw a number of other phenomena, and I hope to tell you of some of them in later issues.

"No further that yeir [1604] bot of a strang meteor, quhilk wes hard and sein in the aire, the seventh day of December. About ane houre befoir the sone rose, the moone schyneing cleir tuo dayis befoir the chainge, in ane calme and pleasant morneing, there wes at ane instant sein gryt inflamatiounes of fyre-flauchtis [lightning? aurora?] in the Eisterne hemisphere, and suddentlie thaireftir thair wes hard a gryt crack, as of a gryt cannoun, and sensibilie markit a gryt glob or bullat, fyrrie-cullorit, with a mychtie quhissilling noyse, flieing from the north-eist to the south-west, quhilk left behind it a blew traine and draught in the air, most lyk ane serpent in mony faulds and linkit wimples; the head quhairof breathing out flames and smooke, as it wald directlie invaid the moone, and swallowit hir up ...... the crack wes hard of all, aiseweill within as without the house, ... Heir was a subject for Poyetis and Prophettis to play upoun, as wes also the strange comett so much discoursit upoun and written on, togidder with the starr that appeirit and cleirly schynit aboune Edinbruche, hard on by the sonne, at ten hours, elevin hours, and at twelve and ane of the clock, in the middel day; prognosticatting, undoutidlie, strang alteratiounes and changes in the world, namely under our climat.

Autobiography and Diary of Mr James Melvill, Wodrow Society, Edinburgh, 1842, p569

Dave Gavine

Eye Safety And Solar Eclipses

A total solar eclipse is probably the most spectacular astronomical event that most people will experience in their lives. There is a great deal of interest in watching eclipses, and thousands of astronomers (both amateur and professional) travel around the world to observe and photograph them.

A solar eclipse offers students a unique opportunity to see a natural phenomenon that illustrates the basic principles of mathematics and science that are taught through elementary and secondary school. Indeed, many scientists (including astronomers!) have been inspired to study science as a result of seeing a total solar eclipse. Teachers can use eclipses to show how the laws of motion and the mathematics of orbital motion can predict the occurrence of eclipses. The use of pinhole cameras and telescopes or binoculars to observe an eclipse leads to an understanding of the optics of these devices. The rise and fall of environmental light levels during an eclipse illustrate the principles of radiometry and photometry, while biology classes can observe the associated behavior of plants and animals. It is also an opportunity for children of school age to contribute actively to scientific research - observations of contact timings at different locations along the eclipse path are useful in refining our knowledge of the orbital motions of the Moon and earth, and sketches and photographs of the solar corona can be used to build a three-dimensional picture of the Sun's extended atmosphere during the eclipse.

However, observing the Sun can be dangerous if you do not take the proper precautions. The solar radiation that reaches the surface of Earth ranges from ultraviolet (UV) radiation at wavelengths longer than 290 nm to radio waves in the meter range. The tissues in the eye transmit a substantial part of the radiation between 380 and 1400 nm to the light-sensitive retina at the back of the eye. While environmental exposure to UV radiation is known to contribute to the accelerated aging of the outer layers of the eye and the development of cataracts, the concern over improper viewing of the Sun during an eclipse is for the development of "eclipse blindness" or retinal burns.

Exposure of the retina to intense visible light causes damage to its light-sensitive rod and cone cells. The light triggers a series of complex chemical reactions within the cells which damages their ability to respond to a visual stimulus, and in extreme cases, can destroy them. The result is a loss of visual function which may be either temporary or permanent, depending on the severity of the damage. When a person looks repeatedly or for a long time at the Sun without proper protection for the eyes, this photochemical retinal damage may be accompanied by a thermal injury - the high level of visible and near-infrared radiation causes heating that literally cooks the exposed tissue. This thermal injury or photocoagulation destroys the rods and cones, creating a small blind area. The danger to vision is significant because photic retinal injuries occur without any feeling of pain (there are no pain receptors in the retina), and the visual effects do not occur for at least several hours after the damage is done [Pitts, 1993].

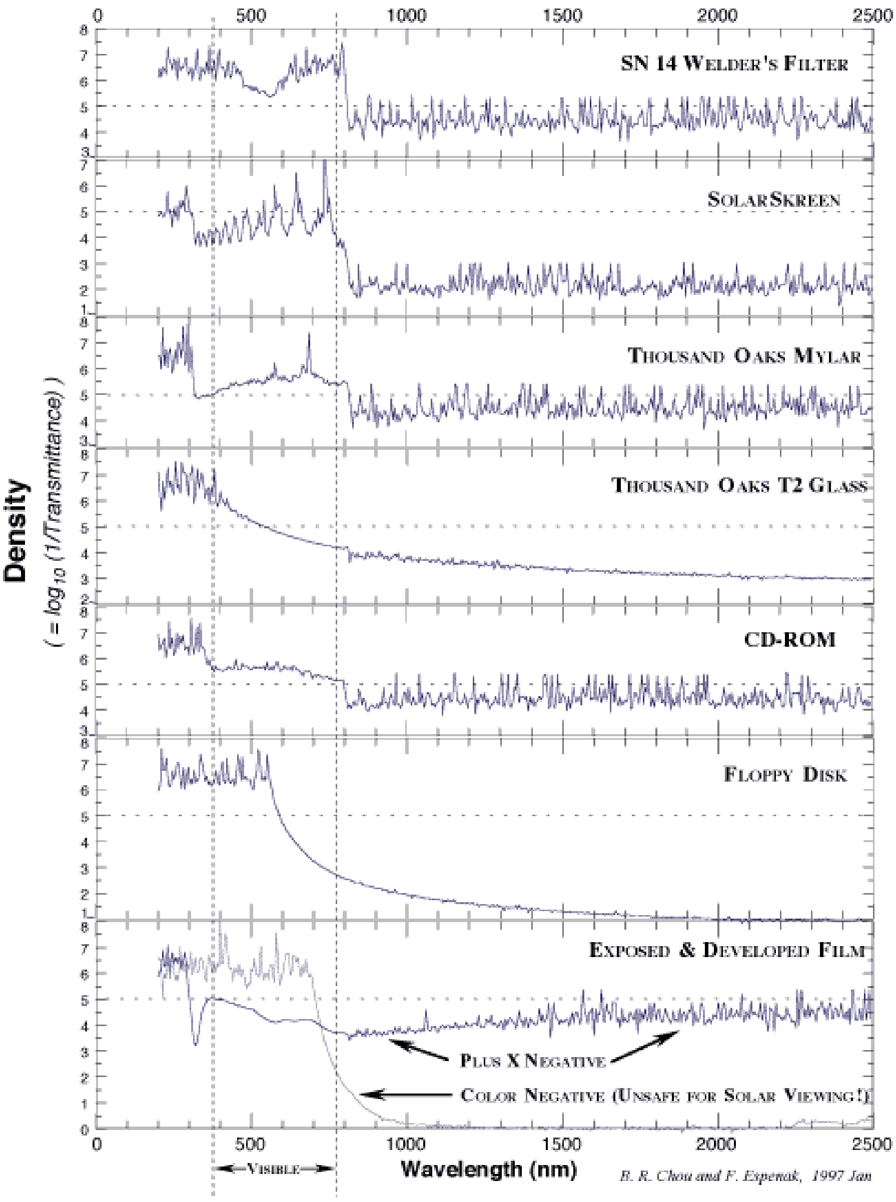
The only time that the Sun can be viewed safely with the naked eye is during a total eclipse, when the Moon completely covers the disk of the Sun. ***It is never safe to look at a partial or annular eclipse, or the partial phases of a total solar eclipse, without the proper equipment and techniques.*** Even when 99% of the Sun's surface (the photosphere) is obscured during the partial phases of a solar eclipse, the remaining crescent Sun is still intense enough to cause a retinal burn, even though illumination levels are comparable to twilight [Chou, 1981, 1996; Marsh, 1982]. Failure to use proper observing methods may result in permanent eye damage or severe visual loss. This can have important adverse effects on career choices and earning potential, since it has been shown that most individuals who sustain eclipse-related eye injuries are children and young adults [Penner and McNair, 1966; Chou and Krailo, 1981].

The same techniques for observing the Sun outside of eclipses are used to view and photograph annular solar eclipses and the partly eclipsed Sun [Sherrod, 1981; Pasachoff & Menzel 1992; Pasachoff & Covington, 1993; Reynolds & Sweetsir, 1995]. The safest and most inexpensive method is by projection. A pinhole or small opening is used to form an image of the Sun on a screen placed about a meter behind the opening. Multiple openings in perfboard, in a loosely woven straw hat, or even between interlaced fingers can be used to cast a pattern of solar images on a screen. A similar effect is seen on the ground below a broad-leafed tree: the many "pinholes" formed by overlapping leaves creates hundreds of crescent-shaped images. Binoculars or a small telescope mounted on a tripod can also be used to project a magnified image of the Sun onto a white card. All of these methods can be used to provide a safe view of the partial phases of an eclipse to a group of observers, but care must be taken to ensure that no one looks through the device. The main advantage of the projection methods is that nobody is looking directly at the Sun. The disadvantage of the pinhole method is that the screen must be placed at least a meter behind the opening to get a solar image that is large enough to see easily.

The Sun can only be viewed directly when filters specially designed to protect the eyes are used. Most such filters have a thin layer of chromium alloy or aluminum deposited on their surfaces that attenuates both visible and near-infrared radiation. A safe solar filter should transmit less than 0.0003% (density~4.5) [See footnote] of visible light (380 to 780 nm) and no more than 0.5% (density~2.3) of the near-infrared radiation (780 to 1400 nm). Figure 24 shows the spectral response for a selection of safe solar filters.

One of the most widely available filters for safe solar viewing is shade number 14 welder's glass, which can be obtained from welding supply outlets. A popular inexpensive alternative is aluminized mylar manufactured specifically for solar observation. ("Space blankets" and aluminized mylar used in gardening are *not* suitable for this purpose!) Unlike the welding glass, mylar can be cut to fit any viewing device, and doesn't break when dropped. Many experienced solar observers use one or two layers of black-and-white film that has been fully exposed to light and developed to maximum density. The metallic silver contained in the film emulsion is the protective filter. Some of the newer black and white films use dyes instead of silver and these are *unsafe*. Black-and-white negatives with images on it (e.g., medical x-rays) are also *not* suitable. More recently, solar observers have used floppy disks and compact disks (both CDs and CD-ROMs) as protective filters by covering the central openings and looking through the disk media. However, the optical quality of the solar image formed by a floppy disk or CD is relatively poor compared to mylar or welder's glass. Some CDs are made with very thin aluminum coatings which are not safe - if you can see through the CD in normal room lighting, don't use it!! No filter should be used with an optical device (e.g. binoculars, telescope, camera) unless it has been specifically designed for that purpose and is mounted at the front end (*i.e.*, end towards the Sun). Some sources of solar filters are listed in the following section.

FIGURE 24: SPECTRAL RESPONSE OF SOME COMMONLY AVAILABLE SOLAR FILTERS



Unsafe filters include all color film, black-and-white film that contains no silver, photographic negatives with images on them (x-rays and snapshots), smoked glass, sunglasses (single or multiple pairs), photographic neutral density filters and polarizing filters. Most of these transmit high levels of invisible infrared radiation which can cause a thermal retinal burn (see Figure 24). The fact that the Sun appears dim, or that you feel no discomfort when looking at the Sun through the filter, is no guarantee that your eyes are safe. Solar filters designed to thread into eyepieces that are often provided with inexpensive telescopes are also unsafe. These glass filters can crack unexpectedly from overheating when the telescope is pointed at the Sun, and retinal damage can occur faster than the observer can move the eye from the eyepiece. Avoid unnecessary risks. Your local planetarium, science center, or amateur astronomy club can provide additional information on how to observe the eclipse safely.

There has been concern expressed about the possibility that UVA radiation (wavelengths between 315 and 380 nm) in sunlight may also adversely affect the retina [Del Priore, 1991]. While there is some experimental evidence for this, it only applies to the special case of aphakia, where the natural lens of the eye has been removed because of cataract or injury, and no UV-blocking spectacle, contact or intraocular lens has been fitted. In an intact normal human eye, UVA radiation does not reach the retina because it is absorbed by the crystalline lens. In aphakia, normal environmental exposure to solar UV radiation may indeed cause chronic retinal damage. However, the solar filter materials discussed in this article attenuate solar UV radiation to a level well below the minimum permissible occupational exposure for UVA (ACGIH, 1994), so an aphakic observer is at no additional risk of retinal damage when looking at the Sun through a proper solar filter.

In the days and weeks preceding a solar eclipse, there are often news stories and announcements in the media, warning about the dangers of looking at the eclipse. Unfortunately, despite the good intentions behind these messages, they frequently contain misinformation, and may be designed to scare people from seeing the eclipse at all. However, this tactic may backfire, particularly when the messages are intended for students. A student who heeds warnings from teachers and other authorities not to view the eclipse because of the danger to vision, and learns later that other students did see it safely, may feel cheated out of the experience. Having now learned that the authority figure was wrong on one occasion, how is this student going to react when other health-related advice about drugs, alcohol, AIDS, or smoking is given [Pasachoff, 1997]? Misinformation may be just as bad, if not worse than no information at all.

In spite of these precautions, the *total* phase of an eclipse can and should be viewed without any filters whatsoever. The naked eye view of totality is not only completely safe, it is truly and overwhelmingly awe-inspiring!

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Footnote: In addition to the term transmittance (in percent), the energy transmission of a filter can also be described by the term density (unitless) where density 'd' is the common logarithm of the reciprocal of transmittance 't' or $d = \log_{10}[1/t]$. A density of '0' corresponds to a transmittance of 100%; a density of '1' corresponds to a transmittance of 10%; a density of '2' corresponds to a transmittance of 1%, etc....

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Eclipse Photography

The eclipse may be safely photographed provided that the precautions outlined in *Eye Safety And Solar Eclipses* are followed. Almost any kind of camera with manual controls can be used to capture this rare event. However, a lens with a fairly long focal length is recommended to produce as large an image of the Sun as possible. A standard 50 mm lens yields a minuscule 0.5 mm image, while a 200 mm telephoto or zoom produces a 1.9 mm image. A better choice would be one of the small, compact catadioptic or mirror lenses that have become widely available in the past ten years. The focal length of 500 mm is most common among such mirror lenses and yields a solar image of 4.6 mm. With one solar radius of corona on either side, an eclipse view during totality will cover 9.2 mm.Adding a 2x tele-converter will produce a 1000 mm focal length, which doubles the Sun's size to 9.2 mm. Focal lengths in excess of 1000 mm usually fall within the realm of amateur telescopes. If full disk photography of partial phases on 35 mm format is planned, the focal length of the optics must not exceed 2600 mm. However, since most cameras don't show the full extent of the image in their viewfinders, a more practical limit is about 2000 mm. Longer focal lengths permit photography of only a magnified portion of the Sun's disk. In order to photograph the Sun's corona during totality, the focal length should be no longer than 1500 mm to 1800 mm (for 35 mm equipment). However, a focal length of 1000 mm requires less critical framing and can capture some of the longer coronal streamers. For any particular focal length, the diameter of the Sun's image is approximately equal to the focal length divided by 109 (Table 1).

Table 1 - 35 mm Field of View and Size of the Sun's Image for Various Photographic Focal Lengths

Focal Length	Field of View	Size of Sun
28 mm	49° x 74°	0.2 mm
35 mm	39° x 59°	0.3 mm
50 mm	27° x 40°	0.5 mm
105 mm	13° x 19°	1.0 mm
200 mm	7° x 10°	1.8 mm
400 mm	3.4° x 5.1°	3.7 mm
500 mm	2.7° x 4.1°	4.6 mm
1000 mm	1.4° x 2.1°	9.2 mm
1500 mm	0.9° x 1.4°	13.8 mm
2000 mm	0.7° x 1.0°	18.4 mm
2500 mm	0.6° x 0.8°	22.9 mm

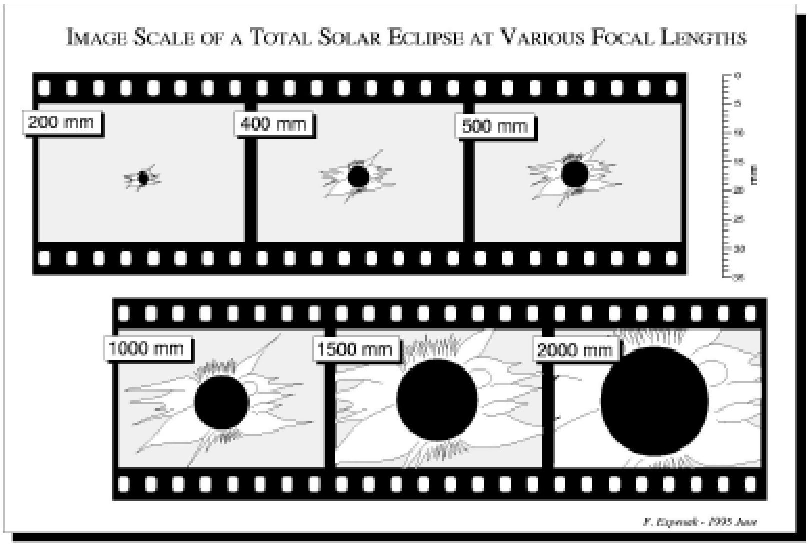

Image Size of Sun (mm) = Focal Length (mm) / 109

A mylar or glass solar filter must be used on the lens throughout the partial phases for both photography and safe viewing. Such filters are most easily obtained through manufacturers and dealers listed in *Sky & Telescope* and *Astronomy* magazines. These filters typically attenuate the Sun's visible and infrared energy by a factor of 100,000. However, the actual filter factor and choice of ISO film speed will play critical roles in determining the correct photographic exposure. A low to medium speed film is recommended (ISO 50 to 100) since the Sun gives off abundant light. The easiest method for determining the correct exposure is accomplished by running a calibration test on the uneclipsed Sun. Shoot a roll of film of the mid-day Sun at a fixed aperture (f/8 to f/16) using every shutter speed between 1/1000 and 1/4 second. After the film is developed, note the best exposures and use them to photograph all the partial phases. The Sun's surface brightness remains constant throughout the eclipse, so no exposure compensation is needed except for the crescent phases which require two more stops due to solar limb darkening. Bracketing by several stops is also necessary if haze or clouds interfere on eclipse day.

Certainly the most spectacular and awe inspiring phase of the eclipse is totality. For a few brief minutes or seconds, the Sun's pearly white corona, red prominences and chromosphere are visible. The great challenge is to obtain a set of photographs which captures some aspect of these fleeting phenomena. The most important point to remember is that during the total phase, all solar filters *must be removed*! The corona has a surface brightness a million times fainter than the photosphere, so photographs of the corona are made without a filter. Furthermore, it is completely safe to view the totally eclipsed Sun directly with the naked eye. No filters are needed and they will only hinder your view. The average brightness of the corona varies inversely with the distance from the Sun's limb. The inner corona is far brighter than the outer corona. Thus, no single exposure can capture its full dynamic range. The best strategy is to choose one aperture or f/number and bracket the exposures over a range of shutter speeds (*i.e.*, 1/1000 down to 1 second). Rehearsing this sequence is highly recommended since great excitement accompanies totality and there is little time to think.

Exposure times for various combinations of film speeds (ISO), apertures (f/number) and solar features (chromosphere, prominences, inner, middle and outer corona) are summarized in Table 2. The table was developed from eclipse photographs made by Espenak as well as from photographs published in *Sky and Telescope*. To use the table, first select the ISO film speed in the upper left column. Next, move to the right to the desired aperture or f/number for the chosen ISO. The shutter speeds in that column may be used as starting points for photographing various features and phenomena tabulated in the 'Subject' column at the far left. For example, to photograph prominences using ISO 100 at f/11, the table recommends an exposure of 1/500. Alternatively, you can calculate the recommended shutter speed using the 'Q' factors tabulated along with the exposure formula at the bottom of Table 2. Keep in mind that these exposures are based on a clear sky and a corona of average brightness. You should bracket your exposures one or more stops to take into account the actual sky conditions and the variable nature of these phenomena.

Another interesting way to photograph the eclipse is to record its phases all on one frame. This is accomplished by using a stationary camera capable of making multiple exposures (check the camera instruction manual). Since the Sun moves through the sky at the rate of 15 degrees per hour, it slowly drifts through the field of view of any camera equipped with a normal focal length lens (*i.e.*, 35 to 50 mm). If the camera is oriented so that the Sun drifts along the frame's diagonal, it will take over three hours for the Sun to cross the field of a 50 mm lens. The proper camera orientation can be determined through trial and error several days before the eclipse. This will also insure that no trees or buildings obscure the view during the eclipse. The Sun should be positioned along the eastern (left in the northern hemisphere) edge or corner of the viewfinder shortly before the eclipse begins. Exposures are then made throughout the eclipse at ~five minute intervals. The camera must remain perfectly rigid during this period and may be clamped to a wall or post since tripods are easily bumped. If you're in the path of totality, remove the solar filter during the total phase and take a long exposure (~1 second) in order to record the corona in your sequence. The final photograph will consist of a string of Suns, each showing a different phase of the eclipse.

Table 2 - Solar Eclipse Exposure Guide

		ISO	f/Number								
		25	1.4	2	2.8	4	5.6	8	11	16	22
		50	2	2.8	4	5.6	8	11	16	22	32
		100	2.8	4	5.6	8	11	16	22	32	44
		200	4	5.6	8	11	16	22	32	44	64
		400	5.6	8	11	16	22	32	44	64	88
		800	8	11	16	22	32	44	64	88	128
		1600	11	16	22	32	44	64	88	128	176
Subject	**Q**		**Shutter Speed (s)**								
Solar Eclipse											
Partial [1] - 4.0 ND	11		-	-	-	1/4000	1/2000	1/1000	1/500	1/250	1/125
Partial [1] - 5.0 ND	8		1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15
Baily's Beads [2]	12		-	-	-	-	1/4000	1/2000	1/1000	1/500	1/250
Chromosphere	11		-	-	-	1/4000	1/2000	1/1000	1/500	1/250	1/125
Prominences	9		-	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30
Corona - 0.1 R_s	7		1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8
Corona - 0.2 R_s [3]	5		1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
Corona - 0.5 R_s	3		1/125	1/60	1/30	1/15	1/8	1/4	1/2	1	2
Corona - 1.0 R_s	1		1/30	1/15	1/8	1/4	1/2	1	2	4	8
Corona - 2.0 R_s	0		1/15	1/8	1/4	1/2	1	2	4	8	15
Corona - 4.0 R_s	-1		1/8	1/4	1/2	1	2	4	8	15	30
Corona - 8.0 R_s	-3		1/2	1	2	4	8	15	30	60	120

Exposure Formula:

$t = f^2/(I \times 2^Q)$

where:

t = exposure time ()
f = f/number or focal ratio
I = ISO film speed
Q = brightness exponent

Abbreviations:

ND = Neutral Density Filter.
R_s = Solar Radii.

Notes:

[1] Exposures for partial phases are also good for annular eclipses.
[2] Baily's Beads are extremely bright and change rapidly.
[3] This exposure also recommended for the 'Diamond Ring' effect.

Finally, an eclipse effect that is easily captured with point-and-shoot or automatic cameras should not be overlooked. Use a kitchen sieve or colander and allow its shadow to fall on a piece of white card-board placed several feet away. The holes in the utensil act like pinhole cameras and each one projects its own image of the Sun. The effect can also be duplicated by forming a small aperture with one's hands and watching the ground below. The pinhole camera effect becomes more prominent with increasing eclipse magnitude. Virtually any camera can be used to photograph the phenomenon, but automatic cameras must have their flashes turned off since this would otherwise obliterate the pinhole images.

For those who choose to photograph this eclipse from one of the many cruise ships in the path, some special comments are in order. Shipboard photography puts certain limits on the focal length and shutter speeds that can be used. It's difficult to make specific recommendations since it depends on the stability of the ship as well as wave heights encountered on eclipse day. Certainly telescopes with focal lengths of 1000 mm or more can be ruled out since their small fields of view would require the ship to remain virtually motionless during totality, and this is rather unlikely even given calm seas. A 500 mm lens might be a safe upper limit in focal length. Film choice could be determined on eclipse day by viewing the Sun through the camera lens and noting the image motion due to the rolling sea. If it's a calm day, you might try an ISO 100 film. For rougher seas, ISO 400 or more might be a better choice. Shutter speeds as slow as 1/8 or 1/4 may be tried if the conditions warrant it. Otherwise, stick with a 1/15 or 1/30 and shoot a sequence through 1/1000 second. It might be good insurance to bring a wider 200 mm lens just in case the seas are rougher than expected. As worst case scenario, Espenak photographed the 1984 total eclipse aboard a 95 foot yacht in seas of 3 feet. He had to hold on with one hand and point his 350 mm lens with the other! Even at that short focal length, it was difficult to keep the Sun in the field. However, any large cruise ship will offer a far more stable platform than this.

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Two One O'clock Guns

On **Saturday 28th August** you may have a chance to see and hear something special. Staff Sargeant Tom McKay, MBE, (otherwise known as 'Tam the Gun') is arranging an exhibition on the history of the One O'clock Gun in the Castle. Although the exhibition itself will not open until early next year, he has planned a special day of events at the Calton Hill on August 28th. Hopefully this will include the Lowland Gunners firing a gun at the hill simultaneously with the Castle time gun. A collection will be taken for N.C.H. Action For Children.

The Observatory will be open during the day with a small exhibition about the Gun. I look forward to seeing many people there.

Graham Rule