of-the-mill objects seen during a known time-interval can provide an interesting comparison with those made by observers who have been sky-gazing especially for meteors.

Another type of casual watch is that carried out from indoors, perhaps through a window or a conservatory roof. For meteor enthusiasts stuck indoors through illness or injury, this can provide a welcome boost to morale, providing a night around a major meteor shower maximum is selected. The restricted field of view will naturally hamper observing, but when meteor rates are notably high, such as around January 2-4, August 10-14 or December 12-14, very acceptable meteor numbers can be spotted.

If you are travelling to a dark-sky site to observe in a group or as an individual, remember to obtain permission from the landowner before setting off, and note that such observing is undertaken solely on the initiative of the people involved. The Society for Popular Astronomy accepts no responsibility for the actions of its members, and the name of the SPA may not be used in any connection.

Further Reading

The SPA's meteor webpages provide more observing notes, tips and other meteor-related information. Most general astronomy books and magazines contain at least some notes about meteors and meteor showers too, but these can be very brief and inaccurate, relying on shower information from decades ago, rather than what recent observations and theoretical models have suggested. Even some of the more accessibly-written specialist books and magazine articles on meteor observing are less helpful and reliable than their authors might like you to believe. Overall, texts published by the IMO tend to use far more up-to-date information, both for observing methods and meteor showers, than most other sources, but if you would like advice regarding the suitability of a specific book for what you are interested in, please contact the Director.

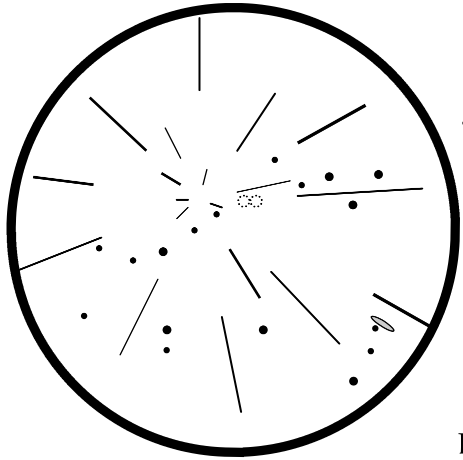
There are also innumerable other Internet sites containing meteor information, and it is often impossible even for quite experienced meteor workers to be certain of the veracity of what is available there. Those with links from the SPA meteor webpages are among the better or more reliable places to visit. The various scientific and astronomical magazines can provide alerts to new material too, including the SPA's printed (*News Circulars* & *Popular Astronomy*) and online (*Electronic News Bulletins*) publications. Public libraries are good for many of the less specialised journals, and your local astronomical society may have useful resources as well.

Conclusion

Please always enclose a stamped, self-addressed envelope (SAE), preferably an A5-sized one, whenever you write to any Section officials if you require a reply, or an e-mail address that will be viable for at least a couple of weeks, as an immediate reply is rarely practical. Note that any envelope larger than A5 incurs the "Large Letter" postage rate, so please remember to provide the correct stamp on your SAE. Always try to submit your results promptly - at most within one month of their being made. Good luck and clear skies for all your observing: your results are eagerly awaited!

References

"Norton's 2000.0: Star Atlas and Reference Handbook" (18th edition), edited by Ian Ridpath, published by Longman Scientific & Technical, Harlow, England, 1989.
"Sky Catalogue 2000.0: Volume 1 - Stars to Magnitude 8.0", edited by Alan Hirshfeld and Roger W. Sinnott, published by Cambridge University Press, Cambridge, England, 1982.



bserving Meteors

The SPA Meteor Section's Instruction Booklet

By

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Introduction

Most people at some time or other have probably seen a "shooting star" dash across part of the sky. This of course is not really a star at all, but is a minute speck of cosmic material called a **meteoroid**, which "burns up" during its passage through the Earth's atmosphere, producing the streak of light which we call a **meteor**. This booklet looks at what meteors are and some of the ways in which we can observe them.

What Are Meteoroids?

Meteoroids which produce naked-eye meteors are mostly very tiny particles, ranging in size from roughly a few tenths of a millimetre across, up to a few centimetres, or occasionally larger. These particles orbit the Sun much as do all other moving bodies in the Solar System, travelling at high speeds relative to the Earth, with velocities between about 11 and 72 km/sec. This means that even the rarefied atmosphere at heights of around 60 to 110 km above the surface is dense enough to cause the particles to ablate ("burn up") owing to frictional heating by collisions with the air molecules. The ablation occurs very quickly. A meteor usually lasts for only a fraction of a second, or perhaps a second or two in rarer cases. Physically, most meteoroids seem to have an open or porous structure, and are very light, "fluffy" and friable - a little like coffee granules. The calculated average density is very low at about 0.3 g/cm^3, roughly the same as cork.

All of these features have a bearing on how bright a meteor any given meteoroid will produce, but generally speaking the size or mass of the body is of greatest importance, with larger or heavier grains yielding brighter meteors. The smaller grains are by far the more numerous, however, with meteoroids large enough to produce fireballs (a **fireball** is any meteor of magnitude -3 or brighter) being rare. From regular visual observations, only about one meteor in every 150 is this bright, while a magnitude -8 fireball occurs on average about once in every 2000 meteors, for instance!

Each year, roughly 40,000 of these particles are large enough to survive their atmospheric flight and reach the Earth's surface. If recovered, we call them **meteorites**. Most fall into the sea and are lost, but the few rescued are of three chief categories, determined by their chemical compositions: 1) Stones - rich in silicate minerals like quartz; 2) Irons - magnetic and contain nickel; 3) Stony-irons - transitional between the other two classes. These groups may well be similar in chemistry to many "ordinary" meteoroids too, as some meteor spectral analyses have suggested.

Origins

Meteoroid particles are thought to originate in asteroids or comets, though some may be remnants from the early days of the Solar System. Particles could also be liberated from asteroids by collisions, but many asteroids (particularly those like the Apollo asteroids which have orbits that pass close to, or cross over, the Earth's) may actually be "extinct" or degassed cometary nuclei.

Comets emit large amounts of gas and dust, especially when close to the Sun, and while the gas will be swiftly removed by the effects of the solar wind, the dust will be rather less affected on a short timescale, and will tend to remain concentrated fairly close to the comet's orbit. On a longer timescale, however, this dusty stream will gradually spread away from the original orbit and become dispersed owing to the effects of the Sun's radiation and planetary gravitational perturbations. This gives rise to the majority of randomly-distributed meteoroids.

In the case of a single asteroidal collision or perihelion passage for a long-period comet, events which may happen only once in several thousand years for any single body, gravity and solar radiation will act to scatter the dust away from its source orbit before a repeat event can happen. Meteoroids thus produced will also end up with essentially randomly-distributed orbits.

If a repeated series of low-velocity asteroidal impacts occurs, such as might happen after the catastrophic destruction of one asteroid by another, or if a comet has a short orbital period (less than about 200 years), then the dust emitted will tend to remain near the parent body's orbit, as fresh material will be deposited on each new orbit to compensate for that which is gradually lost. This concentration is relative only, as the particles in even a very dense meteoroid stream are each separated by several kilometres. These streams too will show signs of spreading and dispersion as time passes, and it is possible, to some extent, to determine the relative age of a stream by examining its physical appearance.

Sporadics and Showers

The randomly-distributed meteoroids give rise to the **sporadic** meteor flux as seen from Earth. Sporadics can be observed on all nights throughout the year, and can occur at any time, coming from any direction.

Meteoroid streams produce **meteor showers** when the Earth intersects their orbit. Shower meteors thus appear only at certain times of year, and can be told from the sporadics in that their paths, if traced back across the sky in dead straight, but imaginary, lines, seem to meet in one part of the heavens which is called the shower's **radiant**. The shower is then named after the constellation or star near which this radiant lies, hence the Perseids seem to radiate from Perseus, the Geminids from Gemini and so forth.

The radiant effect (illustrated in the "O" of "Observing" on the first page, where meteor streaks appear to be emanating from the Perseid radiant) is seen because shower meteors travel towards the Earth on roughly parallel paths. Perspective makes these parallel lines seem to radiate away from a point, just as railway tracks or motorway lanes apparently meet at a "vanishing point" on the horizon when seen from a bridge over them.

very difficult. Attaching the camera to a driven telescope mount will prevent star-trailing and will also allow accurate measurement of the start and end positions of any meteors recorded.

Many older film cameras have mechanical shutters, so keeping the shutter open for a long time is no problem, but digital cameras in particular use considerable battery power during long exposures, which can mean an early end to your imaging if they run down. Thus it would be wise to have more than one charged battery available. Many modern lenses are autofocusing and have no accurate focusing scale. Furthermore, they focus beyond infinity to allow the lens to "hunt" during focusing, so focusing can be a major problem at night. One solution is to focus to infinity in daylight, tape the focusing ring and switch off the autofocus. Digital cameras may be used in conjunction with a laptop which allows you to check focus as you go, and also use software to trigger a series of automatically timed exposures, thus allowing the observer to watch meteors instead of operating the camera.

When reporting your observations, give details on all meteors imaged, as well as the start and end times and the total duration for the exposures, and remember also to state the camera's type, lens-size and settings (e.g. ISO-rating). If you have provided copies of any successful images, please give details on the field of view shown, such as the angular size of the field and its centre in R.A. and Dec, or the prominent star and constellation names, along with the time of the exposure. An information sheet with further tips, and covering some of the more technical aspects of meteor imaging, is also available from the Section.

Triangulation

If a meteor's position against the stars is plotted by two or more observers at sites at least 40 km or so apart, it may be possible to calculate the meteor's height above the surface by triangulation. This can also be done far more accurately if the meteor has been imaged, and if at least one image was taken by video, or another method allowing a velocity estimate, it may be possible to compute the meteoroid's orbit before it entered the Earth's atmosphere. With fireballs, if enough observers record accurate positional information for the meteor, it is sometimes possible to calculate an approximate atmospheric trajectory, and because these very bright meteors can drop meteorites, it may even be practical to try to recover any such fallen objects, if an atmospheric path can be worked-out. Special triangulation projects are organised by the Section from time to time, when instructions are given. Anyone interested in attempting some triangulation work at other times should contact the Director.

Group and Casual Observing

Accurate visual meteor work requires observations from individuals, but several individuals can observe from one site, each recording their own data only. Conversation in such a group should not be too distracting for the watchers, but can be very useful in helping everyone stay awake.

Alternatively, "fun" groups of 4-8 observers plus someone to record the details can be organised, covering the whole visible sky. A rota is needed to ensure the recorder does not get too bored. Only details on the time and type of each meteor need be taken, as well as the general watch notes, since the information cannot be analysed in any serious way. Even this type of watch can have some interest and value however, particularly if part of the group spots a brilliant meteor, for example. Such watching is best carried-out only near a major shower's maximum.

Casual observations of meteors may be made by chance, perhaps when out checking the sky, or may be carried out by individuals or groups who are outdoors at night, but who are not intending to carry out a formal meteor watch. These data can have some use too, providing they are promptly reported to the Section. This is most important for fireballs, but reports on the run-

Sample telescopic meteor plot

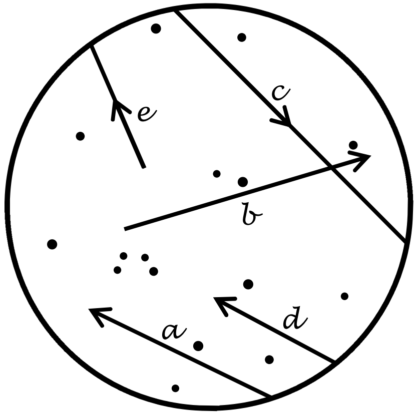
a) oa. Magnitude +6. Late flare. 0.5 second train.

b) aa. Magnitude about +8. Slight fragmentation.

c) oo. Magnitude +1. Very slow. Orange.

d) oa. Magnitude +5. Flare.

e) ao. Magnitude +2. Blue. Swift. 1.5 second train.



Imaging Meteors

Images provide far more accurate meteor positions than visual, or even telescopic, plotting, which can then be used to help determine shower radiants, as well as providing a permanent record of some meteors. Formerly, meteor imaging was carried out using film as photography, but nowadays most astrophotographers use digital cameras. Many frames are needed per successful image using either method, however, so digital is cheaper to run. There is no way of predicting exactly where a meteor will appear, so the main requirement is to image a wide area of sky continuously in the hope that a meteor will appear in the frame. The long exposure means that starlight and, more crucially, the sky background light (usually set by the amount of light pollution) will accumulate, while any meteor appears for only a fraction of a second. So you will need to take a series of exposures lasting up to the limit imposed by the sky background.

Since a meteor is so brief, you need to use the most sensitive system possible. This limits the exposure time to minutes or even fractions of a minute in urban areas. Film can allow longer exposure times than the equivalent digital sensitivity (say ISO 800) because film is notoriously insensitive to low levels of light, such as the sky background - considered a drawback with most other types of astrophotography. Your camera must be able to keep the shutter open for at least 30 seconds, which excludes most compact film or digital cameras, and ideally longer, using the "B" or "bulb" setting which requires the shutter button to be kept down continuously. You will need a cable release for bulb exposures to avoid jogging the camera, while the camera itself must be mounted firmly on a tripod. The lens should have a maximum aperture (*f*-stop) of at least *f*/4, preferably *f*/2.8 or better, and the recording medium's sensitivity should be as high as feasible - ideally at least ISO 400 for film or 800 for digital. Medium- to wide-angle lenses are essential.

Set up your camera and tripod pointing about 50° from the horizon and 30° to 40° from any active shower radiant. Check the lens is set to its lowest *f* number, focused at infinity, with the shutter speed on bulb, and open the shutter using the cable release. The actual exposure time possible will depend on the sky brightness, the film speed, the camera's focal length and aperture, so some experimentation will be necessary at first. Exposure times should not exceed about 20 minutes, as lots of long star trails on the image will make spotting the few meteor tracks

Meteor Activity

The number of meteors observed over a given time - the **rates** - will vary depending on the time of night, the time of year, the sky clarity, the observer's eyesight and, for shower meteors, the elevation of the radiant. Few shower meteors can be expected when the radiant is low in the sky: none at all when it is well below the horizon!

Sporadic activity varies daily (diurnally) and over the course of the year (annually). In order to define these changes, we can make use of the uncorrected mean observed hourly rate (OHR), the actual average number of meteors a good observer might see in reasonable skies, but the mean computed hourly rate (CHR), which corrects this rate to perfect-sky conditions, is more useful. The CHR is almost always somewhat higher than the OHR.

Both sporadic variations are due largely to the position of the Apex of the Earth's Way on the sky. This is the direction in which the Earth is travelling through space. It is the point on the ecliptic 90° west of ("behind") the Sun. The effect produced is similar to a car moving through rain. More raindrops hit the front window than the rear one as the car moves forward. In our terms, more meteors appear when we are facing in the direction of motion - towards the apex - than at other times. In the early part of the night, the apex is well below the horizon. Then, meteoroids have to catch up with the trailing edge of the Earth to be seen, the "rear window" of our car in the rain. At midnight, the apex rises, and as it gets higher in the sky, so the "forwards direction" ("front windscreen") occupies more of the sky, thus improving meteor rates can be expected. The actual effect is to increase average sporadic CHRs from about 4 or 5 meteors per hour (m/h) in the early evening, to around 16 or 17 m/h in the pre-dawn hours, though there are variations in the rate over the year.

The sporadic annual rate changes occur partly because of the constantly altering elevation of the apex as it moves along the ecliptic. From the UK, the apex is highest in the early morning sky from about August to October, lowest between approximately February to April. The higher the apex, the greater the sporadic rate, in general. However, the change is partly because of an increased meteoroid concentration in the part of the Solar System the Earth occupies in the latter months of the year. In practice, mean CHRs are usually about 6-8 m/h from February to May/June, rising after that to about 15-17 m/h in November/December, though again short-term fluctuations are also seen.

Shower meteors can be observed only when their radiant is active. Shower rates vary depending on the radiant elevation and how close to a maximum the shower is. Rates will always be lower away from a shower's peak and when the radiant is low in the sky. No two showers have identical activities, and changes are also apparent from year to year as well.

As with the sporadics, we could use an OHR to examine the actual activity, but it is more reliable to use a mean computed **Zenithal Hourly Rate** (ZHR) which is the corrected rate an ideal observer would see under perfect skies with the radiant directly overhead. This is then comparable to the sporadic CHR and, as with that rate, shower OHRs will normally be lower than the ZHR.

Aims of the Section

The general function of the Section is to make good astronomers, and in particular meteor observers, of its members. By following the instructions and carrying out observations as detailed later, you will be doing some original work, which is the best way to learn. Never be afraid to ask questions if you are not certain what to do or want more information on any meteor-related topics, and do not worry about your inexperience or making mistakes when you start out. Every experienced observer made - and still occasionally makes - mistakes; that is how they gained their experience. Regular observing at all times of year, **NOT** just near the maxima of major meteor showers, is how to become a better meteor watcher!

All observers, whether veteran or novice, are to some extent unreliable, as two people at the same place seeing the same meteor can (and will) give totally conflicting reports of the event, while still believing their own is the correct version! Discussing the meteor between members of an observing group is definitely not recommended. The important thing is to try to record the details that actually happened, and this is not always the same as what you thought you saw. Remember, practice makes perfect!

Meteor Showers

A separate listing of meteor showers known to be active during the year accompanies this booklet. Since some meteor shower parameters change from year to year, this enables us to keep the shower listing as up-to-date as possible. Notes on specific showers are also given on that sheet, and further information can be found regularly in the SPA *Electronic News Bulletins*, the SPA online Forums, the *News Circulars* and *Popular Astronomy*.

Making Meteor Observations

There are a number of ways of observing meteors. Radio sets can be used, and some amateurs follow meteor activity 24 hours a day with suitable radio receivers. Although this is a technically-challenging field, a separate *Radio Meteor Observing Information Sheet* is available for those considering trying. Automated CCD video systems are used by amateurs to collect high-quality data on meteor activity every clearer night in places. Again, this work requires some technical knowledge, and those seriously interested are recommended to contact the International Meteor Organization's (IMO's) Video Commission for further advice. Telescopes and binoculars can be pressed into service, and enable meteors too faint for the unaided eye to be observed, while electronic and film cameras can be useful in imaging particularly the brighter meteors. Some notes on both these methods are given later. What makes meteor observing virtually unique in modern astronomy, however, is that valuable data can still be collected using only the naked-eye.

There are two main ways in which such visual meteor observations can be made. Meteor paths can be plotted onto special gnomonic star charts, the only sort of sky map on which meteors can be drawn as straight lines (the star charts in, for instance, "Norton's 2000.0" are not suitable for this), although the method does require experience and regular practice to achieve the necessary accuracy. Detailed studies of minor showers can be carried out in this way, and special Meteor Section projects are sometimes organised to make meteor plotting reports, when charts and instructions are issued.

The alternative to this is the standard visual watch which all Meteor Section observers are encouraged to perform regularly. In this, the watcher goes outside on a clear, dark night well away from full Moon, and observes the sky for as long as possible, writing down, or speaking into an electronic voice recorder, the details of individual meteors as they are seen. About five nights to either side of full Moon each month are rendered more or less useless for meteor work by its presence. The actual nights lost vary slightly during the year.

Some basic items of equipment useful for most types of nocturnal outdoor watching will be required, which we can call "The Observer's Kit", as detailed in the box opposite.

It is vital to remain warm and comfortable at all times, or your concentration may wander away from the sky. It is equally important that you should not be so tired as to have to struggle to stay awake. Observations are only worth doing while you remain alert. Drinks or snacks taken

Fireball Magnitude Estimates

Fireball brightness estimates are never easy, as convenient comparison objects are rarely close by. Above magnitude -5 (Venus), there is only the Moon as a guide, and converting from an area of light (the Moon) to a point (the meteor) brings its own problems, so the brilliance of such meteors is usually more guess than estimate.

The commonest case is to overstate the fireball's brightness, so it can be useful to be critical of your own estimates and to keep your bright-source calibration up to scratch by checking the apparent and actual magnitude of Venus regularly, as well as the various lunar phases. Shadows may be cast by meteors as "faint" as magnitude -7 or -8 at times, though this fact is often used to suggest a greater brightness. If in doubt, use a possible range of values, e.g. -7 to -9, rather than a specific figure.

Anyone spotting a fireball, whether on a meteor watch or not, should report it to the Section as soon as practical, and should also send a copy of the sighting to the IMO's Fireball Data Center (FIDAC). A special *Fireball Observing Information Sheet* is available with more advice.

Telescopic Observing

Although long regarded as a less popular way of watching meteors, telescopic results are of much greater accuracy than those obtained by naked-eye meteor plotting.

The major item of equipment needed is a small telescope or a pair of binoculars (7x50s or 10x50s are ideal) which should be firmly mounted on a tripod or other suitable stand so as to allow you to follow your selected field of view in comfort and with ease. In choosing the instrument, it is important to remember that larger apertures and higher magnifications mean that you will be looking at a smaller area of sky, which will reduce the number of meteors seen.

Each field is best centred about 25° to 30° from the known or suspected shower radiant under examination, and around 35° to 65° from the horizon. **Pairs** of fields need to be observed at different angles to this radiant, to allow the radiant to be defined during an observing session. Alternate between the fields at about 20-30 minute intervals, with a 5-minute break or so in between. Make sure both fields can be observed comfortably using your equipment.

Observing notes should include the date, watch times and durations, your name and site location as usual, along with the type of equipment employed, the size of its primary lens or mirror (depending on whether it is a refractor or reflector respectively), the magnification used and the field diameter in degrees. This latter item can be worked out (if not already known) following the method in "Norton's 2000.0", page 72, or any good general astronomy text.

Once decided upon, each field centre's co-ordinates in R.A. and Declination must be recorded and the field stars need to be drawn on to a pre-prepared circle of about 8 cm diameter. Also write down the field limiting magnitude.

During the watch, positions for all meteors seen are to be plotted onto your star-field sketch. When a meteor appears, "freeze" your attention on it until you are certain of the path details, and then copy the track down. A 15 cm ruler is useful for this purpose. Mark the line with an arrow to show the meteor's direction of motion, and assign each meteor a letter, which is then keyed to a written description. This description should include the letters "a" or "o" for each end of the trail ("a" = inside the field, "o" = outside it; e.g. "aa" means a meteor completely in the field of view, "oa" one which ended in the field having started outside), how bright it was compared to the field stars, its speed, any colour or train. Page 10 shows a sample telescopic meteor plot.

Rates should be similar to normal visual ones, as many fainter meteors become visible to compensate for the restricted field of view, and most showers exhibit some telescopic activity.

will leave a train, and the length of time taken for it to fade from view should be estimated in seconds or partial seconds as accurately as possible. With long duration trains lasting sometimes for minutes (very rare indeed), a degree of spreading or kinking may be apparent owing to high-altitude winds, and if this is seen a series of sketches should be done to show what happened. Note that the train has nothing to do with the time the meteor was seen in the sky for, nor the length of its path. The train is visible only after the meteor has vanished.

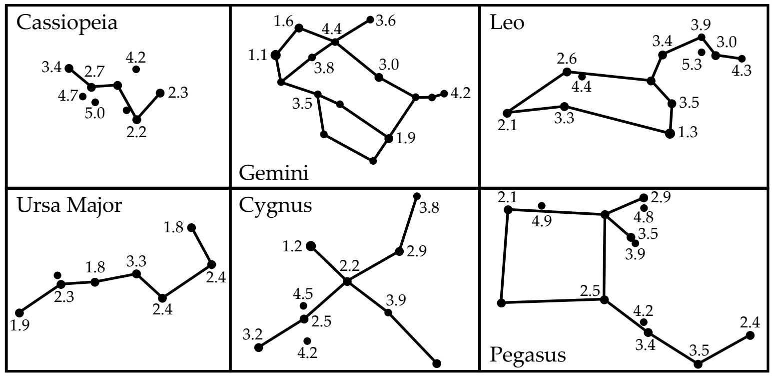
- **Notes**: This column allows the further description of the meteor. Features such as its relative speed (use a scale of 0 to 5, where 0 = point source/stationary, 1 = very slow, 2 = slow, 3 = medium, 4 = swift, 5 = very swift), any exceptional colour, sudden flares in brightness, or any flickering should be noted here. For fireballs, try to fix the path through the stars, or with respect to landmarks on the horizon in the case of a rare daylight fireball. Give this as a sketch, or use a star atlas to give co-ordinates for the start and end points of the track. Remember to note the direction of movement too.

Finally, after you have written up all your meteor details, fill in the **Sheet _ of _** section at the top right-hand corner of the forms, noting which sheet is which for the night in question and how many sheets were used that night in total. For instance, if three forms were used to record a night's observations, they should be numbered Sheets 1 of 3, 2 of 3 and 3 of 3 respectively.

Watches done on the same night can be recorded on one form, or set of forms, but mark all start and end times clearly and give a total duration for all watches on the night as well as for individual watches. Observations done on separate nights **must** be recorded on separate forms, however.

Constellation charts to aid in the estimation of meteor magnitudes

Non-variable stars of spectral types A, B, F, G and early K have been chosen in preparing these charts from "Sky Catalogue 2000.0" information.



The magnitudes of objects suitable for comparison with brighter meteors include:

-12.6^m = Full Moon	-1.5^m = Sirius (α CMa)	+0.4^m = Procyon (α CMi)
-11.5^m = 11 or 18 day Moon	0.0^m = Arcturus (α Boo)	+0.8^m = Altair (α Aql)
-10.1^m = 1st/last qtr. Moon	0.0^m = Vega (α Lyr)	+1.0^m = Spica (α Vir)
-7.9^m = 4 or 24 day Moon	+0.1^m = Capella (α Aur)	+1.2^m = Fomalhaut (α PsA)
-4.8^m = Venus (brightest)	+0.1^m = Rigel (β Ori)	+1.8^m = Mirfak (α Per)
-2.9^m = Jupiter (brightest)		

out should be consumed or disposed of only during breaks in your watch, to avoid accidental injuries. Note that caffeine in tea and coffee only helps prevent sleep, which is not the same as helping to keep you awake and alert! Always be well-prepared.

You should watch as large an area of sky as you comfortably can. More meteors will be seen at about 40°-50° from the horizon than elsewhere, and this is also a good optimum distance from a radiant to watch for shower meteors. Beware of flashes from satellites or aircraft which can look rather like very short or **point-source meteors** (these are meteors travelling directly towards you and resemble brief points of light like a star). Artificial sources will usually reveal themselves by repeat flashes nearby soon afterwards. Birds, bats, moths and even windblown leaves can sometimes catch stray lights and may look very meteoric, though they often fly on erratic courses, not the straight-line trajectory of meteors. Do not fix your gaze in an area for too long, as your visual system rapidly becomes "bored" that way, and your field of view may become a uniform grey. Moving your eyes to a new spot should alleviate the problem immediately.

Watches should continue for as long as possible, in practice as long as clouds or fatigue permit. A minimum duration of one hour should always be attempted, assuming conditions do not intervene, while the maximum could be as long as the night. Very long watches - six hours or more unbroken - should not be undertaken lightly. However, never give up on a watch, or the possibility of one, too early. Cloud or haze may move away in an hour or two, and much better skies later could be missed. Weather forecasts on television, radio (especially local bulletins) or the Internet, can be followed as rough guides to what might happen, but they are not infallible!

The Observer's Kit

- ☑ **Chair**: A reclining deck-chair is highly desirable. This should be set up firmly on your observing platform (e.g. garden path or back lawn), ensuring it will not rock about or tip up.
- ☑ **Clipboard**: Plus several sheets of scrap paper, enough to record the observing details.
- ☑ **Pencils**: Take several in case of broken points, but beware of cut fingers on points which are too sharp. An alternative to pencil & paper is an electronic voice recorder.
- ☑ **Watch**: This must be accurately set; digital types are preferable.
- ☑ **Torch**: This needs to be red or red-covered (use red paper or cellophane) to see by without ruining your night vision.
- ☑ **Clothing**: Several thin layers of warm clothes are useful, but they must not fit tightly as this restricts the blood circulation and leads to cooling. Even summer nights can get very cold on occasion, so never neglect this aspect of the kit. Remember especially head, hands and feet.
- ☑ **Sleeping-bag**: Or blankets (or both!) to help further insulate both feet and legs from cold concrete or the wind.
- ☑ **Radiants**: Positions of active meteor shower radiants should be known. Small charts taped to your clipboard can assist here. A working knowledge of the area of sky to be observed is also helpful.
- ☑ **Magnitudes**: Memorise the magnitudes of some comparison stars to use in estimating the brightness of meteors spotted; use the constellation charts in this booklet too.
- ☑ **Dark adaptation**: Allow plenty of time for your eyes to accustom to the night sky, avoiding all blue lights before-hand. The time taken to fully dark-adapt from a well-lit room is usually 20-40 minutes.
- ☑ **Enthusiasm**: To get you out observing.
- ☑ **Stamina**: To keep you out observing.

Details to Record

Naked-eye report forms for recording your watch details are available from any Section official or on the SPA website. These should be completed as described below. Always make sure you fill in the forms as neatly as possible, using the reverse where there is insufficient room to give the information on the front. Any mistakes should be crossed out with a single line and the correct data added clearly nearby. Please refer to a copy of the report form while reading this section.

The top part of the form refers to items concerning the whole watch.

- **Date**: Always give this as the double-date over midnight no matter when in the night the watch was done, in the form year/month/date. For instance, a watch started at 1.15 a.m. on December 14th 2009 would have the date 09/12/13-14.
- **Observer**: Your name.
- **Site**: Note the name of the nearest town or village to your observing site, the county, and the latitude, longitude and approximate height above mean sea level of the place you observed from. This information can be found on an Ordnance Survey map of the area at your local library or via the Internet.
- **Lim. Mag.**: This abbreviation stands for "limiting magnitude" and is a measure of sky clarity. It is defined as the magnitude of the faintest star you can just see with averted vision, using exactly the same level of concentration as while meteor watching. Ideally, this should be for the area of sky observed, but the chart opposite showing the area near Polaris in Ursa Minor can be used instead. A series of other limiting magnitude charts are available for a small charge to cover copying costs; please write for details. Any changes in the lim. mag. must be recorded on the back of the form together with the times at which they happened. The best lim. mag. you can expect is about +6.5 to +7.5 in perfect skies, but +5.0 to +6.0 is common from many better UK sites. The faintest meteors visible will be mostly one or two magnitudes brighter than the lim. mag. If the lim. mag. is much worse than +5.5, observed meteor activity drops rapidly, so a dark-sky site is worth seeking.
- **Conditions**: If clouds are present, estimate the percentage of your field of view obscured by them (**NOT** for the whole sky). If this changes, record an average value about every 15 minutes, using the reverse of the form if necessary. With an average of more than 20% cloud in an hour, observed rates tend to fall quite quickly. Other items to mention here include the presence of the Moon, haze, fog, mist or anything else you feel to have been of importance.
- **Watch Times**: Record all timings in Universal Time (UT), the same as Greenwich Mean Time, GMT. When British Summer Time (BST) is in operation, one hour must be subtracted to convert BST to UT. The time should always be quoted as a 24-hour clock, e.g. 11:10 p.m. GMT becomes 23:10 UT; 12:27 a.m. GMT becomes 00:27 UT. **Start** and **End** your watches at a specific time, rather than waiting for "just one more meteor", note these times down and give the watch **Duration** in hours and minutes. Remember to allow for any "dead" time during breaks or while you were not watching the sky.

The bulk of the form is set aside for recording details on each individual meteor seen. Use at least one line per meteor when writing up your observations after the watch. In the field, as little time as possible should be spent taking notes on a meteor, but ensure that all the relevant facts are correctly put down. Portable voice recorders can also be used for this purpose, although they need to be protected so as not to malfunction when in damp, cold, outdoor conditions. The form columns, and hence items to look out for, are as follows.

- **Time**: The meteor's appearance time to the nearest minute in UT. Timings to the nearest five seconds should be given for unusual meteors or fireballs.
- **Mag.**: This stands for magnitude, an estimate of the brightness of the meteor to the nearest whole magnitude, as compared to some known nearby stars at the same elevation as the meteor. The constellation charts on page 8 should be used as a guide. Remember not to jump magnitude 0 which lies between magnitudes +1 and -1, and note the minus sign "-" if the meteor was of negative magnitude.
- **Type**: A meteor's type is either shower or sporadic. Always give the shower's name to avoid any ambiguity, either in full or using the standard IMO three-letter code given in our *Meteor Showers List*, and "SP" for sporadic. **Please do not use other abbreviations**. A rigid straight edge such as a ruler or broom-handle is very useful for tracing meteor paths back across the sky to see if they belonged to a given shower or not. If the path did not seem to intersect with a known active shower radiant, then the meteor was a sporadic.
- **Rel.**: "Reliability", a measure of how well you saw the meteor, using an A, B, C scale. Class A = very well seen, Class C = poorly spotted or where some details were uncertain, while Class B = everything else. Suspected or doubtful objects should not be recorded at all, and do not be surprised if many of your meteors are of Class C.
- **Train**: Some meteors, after they have gone from the sky completely, leave a persistent glowing wake or train of ionized gas after them. Only a few bright, usually swift, meteors

Limiting Magnitude Chart

Stars to magnitude +6.5 within 10° of the North Celestial Pole are shown. Numbered star details are given in the table below, while the two lettered stars are given for easier comparison with the small diagram of Ursa Minor under the table. Star **1** is α UMi (Polaris), star **2** δ UMi and star **b** ε UMi. Stellar data were from "Sky Catalogue 2000.0". Only stars without visible companions and those not known to be variable have been selected.

Star	Mag.	Spectrum
1	2.0	F8
2	4.4	A1
3	5.3	F5
4	5.3	A0
5	5.5	A2
6	5.6	F0
7	5.8	F5
8	6.2	A2
9	6.3	F0
10	6.5	A5