PUPIL
RESEARCHER
INITIATIVE

Shooting Stars

Setting the Scene

You will be carrying out research into meteors ('shooting stars'). The STAR Centre at Sheffield Hallam University provides information to users of the World Wide Web about meteors. Your research findings can be sent to the STAR Centre to add to the data base.

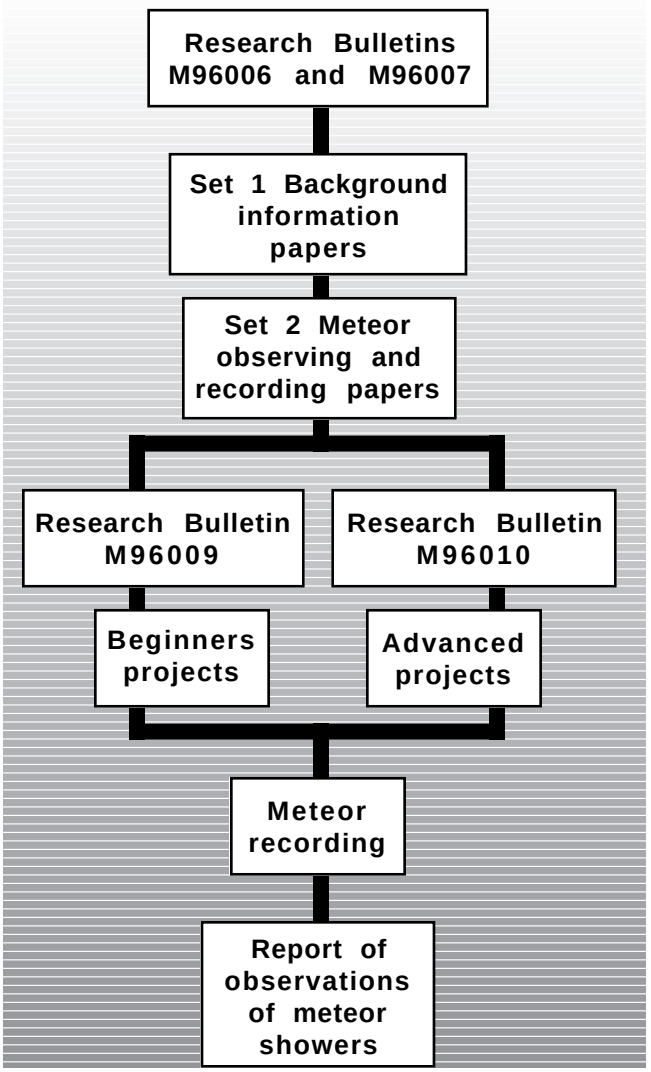
Pupil Research Brief

Study Guide

Syllabus Coverage *Science you will learn about in this Brief*

- ❑ the stars in the night sky stay in fixed patterns called constellations
- ❑ comets have orbits which are far from circular
- ❑ comets are very much closer to the Sun at some times than at others - this is why they can be seen

Route through the Brief



Outcome Checklist

You will carry out observations of meteor showers. You will write a report based on your findings. You should make sure you produce the following items as you work through the Brief

Set 1 background information papers

- ❒ notes about the nature, appearance and origin of meteors
- ❒ notes about the structure, orbits, and luminescence of comets
- ❒ notes about meteor showers
- ❒ notes about asteroids
- ❒ notes about meteorites

Research Bulletins M96009, M96010 and Set 2 Meteor observing and reporting papers

- ❒ a plan for carrying out the investigation on your chosen project
- ❒ a report of the observations you have made including analysis of the results

STAR Centre

Sheffield Hallam University **Research Bulletin:** M96006

Subject: Meteor research request
From: Director of Star Centre
To: PRI Schools
Date

Research Request

STAR Centre invites observers in schools to take part in a nationwide research project on meteors. Eight projects have been identified, four of which are suitable for researchers with no previous experience, and four for people with some knowledge of the night sky. Even if you have never seen a 'shooting star' you can take part!

You can observe alone, but working in a group is recommended. As a group you will see more meteors and it is also safer and more fun to be part of a team. No special equipment is needed because meteors are observed using the naked eye.

The main aim is to record the times at which meteors appear as accurately as possible. The results lead to analysis of the frequency of meteors and conclusions about the activity of a meteor shower. This kind of project can be done by almost anyone.

More advanced projects ask observers to record colours and brightness of meteors in order to add estimates of the size and texture of meteor particles. You should only try these projects if you can recognise the constellations and main stars - so there is an incentive to learn them!

This research brief is designed to help you to find out more about meteors and then to plan and carry out meteor observation during a meteor watch. You can send your results and conclusions to STAR Centre to build up a broad picture of meteor activity and shower characteristics.

Why watch meteors? Well, this research is important because it tells us about the activity of meteor showers and can help predict outbursts or meteor storms. It can help to identify new meteor streams and assess the sizes of particles in known showers. Each meteor marks the fiery death of an original piece of our Solar System - and seeing them is great fun!

Dennis Ashton

Director, STAR Centre

STAR Centre

Sheffield Hallam University **Research Bulletin:** M96007

Subject: Meteor research
From: Director of Star Centre
To: PRI Schools
Date

Meteor Research Schedule
There are three sets of papers attached to this research schedule. They are:

Set 1- the background information
Set 2 - meteor observing and recording.

Your research schedule is in three sections. It is important to complete all three.

Section 1 - Background Information
Use the magazine articles in Set 1 to help you write brief research background notes about meteors. Include the following as headings and sub-headings to help structure your notes.

- **Meteors** - what they are, their appearance, where they come from, why they glow.
- **Comets** - their structure, their orbits, where they come from, why they glow.
- **Meteor showers** - why they happen, their appearance, meteor radiant.
- **Asteroids** - what they are, their orbits.
- **Meteorites** - what they are and where they come from.

Section 2 - Planning and carrying out your meteor watch
Choose an observing project from the list in Star Centre Research Bulletin **M96009 and M96010.** Then write your plan using the information in Set 2 papers and the guidelines below.

1. The name of the meteor shower and the aims of your project.
2. The date, observing place, names of observers and starting time.
3. An equipment checklist with the names of people responsible for bringing each item.
4. An alternative plan in case of poor weather on your chosen night.
5. Carry out your meteor watch and write down your results. Meteor timings are the most important of the results.

Section 3 - Analysing your results
1. Write up your results neatly on a fresh *Meteor Section Visual Report* table.
2. Use the results to draw graphs of meteor rates, etc. Use the paper *Meteor Recording 2* as a guide
3. Write up your conclusions, word-processed if possible.

You can if you wish send a copy of your results and conclusions to STAR Centre, Centre for Science Education, Sheffield Hallam University, Collegiate Crescent, Sheffield S10 2BP. Staff at STAR Centre will process your results along with those from other schools and make available our overall findings. You could e-mail them on d.ashton@shu.ac.uk

STAR Centre

Sheffield Hallam University **Research Bulletin:** M96008

Information sheet: Main meteor showers through the year

Shower name	Dates of Activity	Date of Maximum Activity	ZHR*	Comments
Quadrantids	Jan 1-6	Jan 3	100?	Very brief maximum. Blue and yellow meteors.
Lyrids	Apr 19-25	Apr 21	10	Fast moving meteors.
Eta Aquarids	Apr 24-May 20	May 5	35	Fast meteors, lasting trails. Difficult to observe in UK.
Perseids	Jul 25-Aug 20	Aug 12	80	Very rich shower with many bright meteors. Good for photography.
Orionids	Oct 15-Nov 2	Oct 21	30	Fast meteors with bright trails.
Taurids	Oct 15-Nov 25	Nov 3	10	Slow meteors.
Leonids	Nov 15-20	Nov 17	varies	Fast meteors, good trails. Occasional storms - next due in 1998/99.
Geminids	Dec 7-15	Dec 13	100	Best shower in most years. Fast meteors, often yellow. Good for photography.

*Note: the column ZHR (Zenith Hourly Rate) indicates the maximum number of meteors visible per hour under theoretical ideal conditions. The actual number of meteors per hour which can be expected to be seen is much less. The ZHR gives an indication of the activity of the meteor shower at its peak.

Set 1 paper 2

Cosmic Streakers

"Most people have seen a 'shooting star' flash across the sky. But what is a shooting star?

What it is not is a star! Shooting stars,or meteors to give them their proper name are just small pieces of space debris, like grains of sand. When they hit our atmosphere the friction of collision destroys them in a brief flash of light."

Sarah Ashton

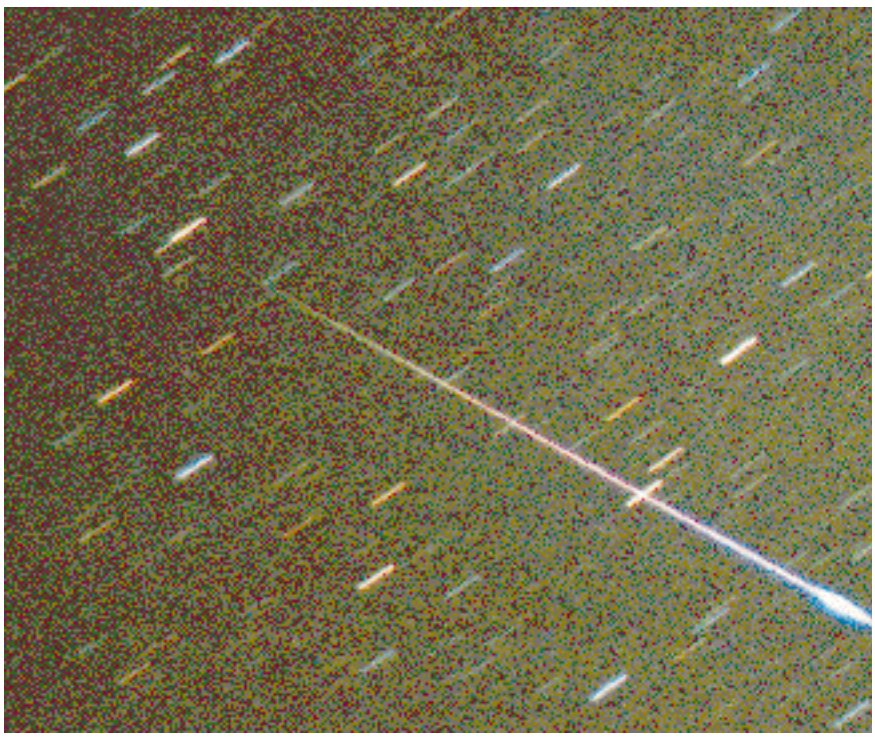


Figure 1. A meteor streaks across the sky

Meteor particles - called meteoroids - are usually very small, about the size of a grain of sand but with the texture of a coffee granule. When they enter the Earth's atmosphere they become visible as meteors.

When streams of particles left in the wake of comets cross the Earth's orbit, we see a meteor shower. They hit our atmosphere at great speed - between 40,000 and 250,000 km/hour (a bullet travels at about 3,500 km/hour). They burn up some 90km above the Earth in a flash of friction. The streak of light lasts for a second or two and looks like a falling star - this is a meteor.

The comet connection

Most meteors come from comets. When a comet passes close to the Sun it leaves a trail of particles behind it. The particles stream out behind to form a continuous ring of dust moving in the same orbit as their parent comet. As the Earth revolves around the Sun in its yearly orbit it can crash into the comet dust. The stream of particles produces lots of meteors in a short space of time. This is a meteor shower. Because the

Earth hits the meteoroids at the same place in its orbit each year, the meteor shower happens at the same time each year.

The meteoroid particles travel parallel to each other in orbit around the Sun. When they burn up in the Earth's atmosphere they are still on parallel tracks. But to an observer on Earth the meteors spread across the sky like snow flakes in the headlights of a moving car.

So shower meteors seem to come from the same place in the sky. The star pattern they fly from gives the shower its name. So the Perseid shower in August emanate from the constellation Perseus and the December Geminids come from Gemini. If the path of each meteor is traced backwards, the tracks meet in a small area of sky called the radiant.

Figure 2. Shower meteors seem to spread out from a single area of the sky, known as the radiant, marked by an x.

Loners

Some meteors do not belong to showers. These stray pieces of space dirt burn up in any direction on any night in the year. Lone meteors are called sporadics. In clear weather you might see 5 or 6 sporadic meteors in a night.

Asteroids and hard meteors

Some meteor particles come not from comets but asteroids. Asteroids are large space rocks and most orbit between Mars and Jupiter. Some asteroids have elongated orbits which bring them towards the Earth. Fragments of these asteroids can break off to form meteors. Sometimes a larger fragment survives its fiery ride through our atmosphere to hit the Earth's surface, then it is a meteorite. Asteroid meteors are denser and harder than those from comets. Their trails last longer as they streak across the sky. The December meteor shower, the Geminids, are fragments of asteroid 3200 Phaeton.

Fireballs

Large chunks of space rock, perhaps as big as a pebble, burn up with tremendous energy. They make super bright meteors called fireballs. A meteor becomes a fireball if it is brighter than the planet Venus (star magnitude -5). Fireballs are rare events. Meteorites often create fireballs and sighting of their trails can help astronomers to find the meteorites after they have hit the ground.

International Astronomy Association: Annual Meeting 1995

Research Abstract

Mechanism of meteor luminosity

Summary of paper presented by Prof G. Mitchell

1. Misconceptions

In many popular books the impression is given that meteors produce streaks of light as they cross the sky because they 'burn up' in the atmosphere.

In fact this is an over-simplification. My talk to the IAA will describe a more acceptable explanation of meteor luminosity.

2. Meteor luminosity

Meteoroid particles enter the Earth's atmosphere with velocities between 10km/sec and 70km/sec (a bullet travels typically at 1km/sec).

The dramatic change in environment from almost nil density in space to high density in Earth's atmosphere causes a sudden change of a little mass into a lot of energy. The meteor drills into our atmosphere like a bullet hitting a brick wall. The surface of the meteoroid tears at atoms of air, stripping off their electrons. The passage of the meteor leaves a tube of ionised gas in the atmosphere - positive ions and free electrons.

Electrons then recombine with the atomic nuclei, a process which produces photons - particles of light. These photons are emitted along the line of the meteor's path and we see a streak of light cross the sky - a 'shooting star'. Occasionally the disruption is so great that the emitted light persists after the passage of the meteor particle and we see the glow of a meteor train which can last for several seconds.

Faster meteors emit light at higher altitudes than slower ones. The fastest 'burn up' as high as 120km, whilst slower meteors penetrate down to 80km.

GM/IAA1995/SUM

The crash of Comet Shoemaker-Levy into Jupiter focussed the world's attention on comets. Just what are they? Jane Walker reveals that comets are.

Set 1 paper 4

Ghosts of the Solar System

The sight of a bright comet hanging in front of the stars is one of the wonders of nature. In the past, comets were taken as signs of death and destruction, warnings from the gods. Now we know that their light comes from huge envelopes of thin gas - they are ghosts from far beyond the planets.

Jane Walker is curator of Mayfield Observatory in West Virginia and discoverer of two asteroids. She has not discovered any comets - yet!

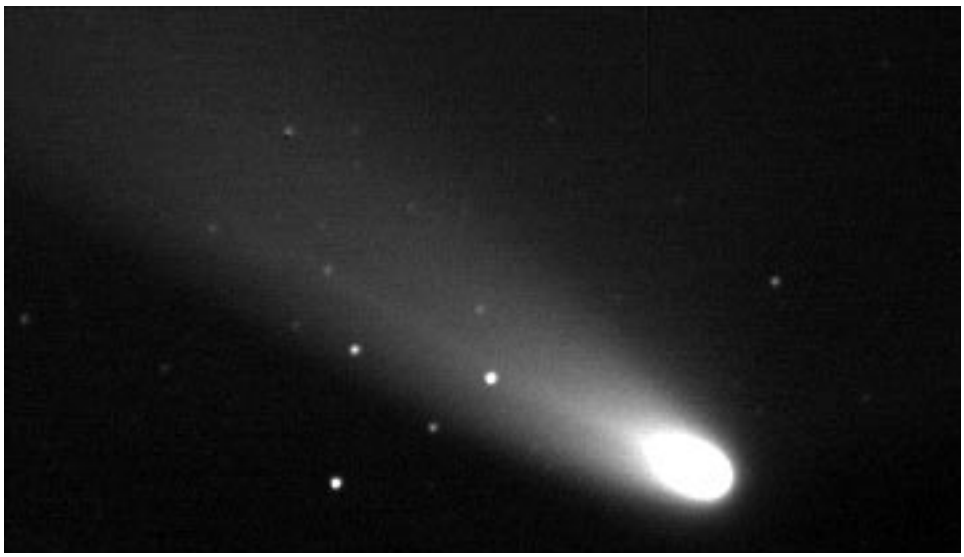


Figure 1. Comet Hayuketake which was visible from the UK during the spring of 1996

Comet orbits

Comet orbits are very elliptical, going close to the Sun and then out to or beyond the outer planets. Some comets return regularly to the Sun and are called periodic comets. Halley's Comet, with an orbital period of 76 years, is a periodic comet. Other comets travel so far from the Sun that they take hundreds or thousands of years to complete one orbit. These are non-periodic.

Into the Hall of Fame?

Comets only become bright when they approach the Sun and each year a handful of new comets appear. Each comet is named after its finder, so there is great competition to find them. Sometimes more than one person discovers a comet, and it receives a combination name. Comet Shoemaker-Levy was discovered by Eugene and Caroline Shoemaker and David Levy, all expert comet hunters. Comet hunting takes skill and dedication but is open to everyone. **Could you join the comet Hall of Fame?**

Set 1 paper 4 ctd.

Dirty snowballs

A comet is a lump of ice, rocks and dust a few kilometres across - a dirty snowball. Deep in space this comet nucleus is too small to be seen. But as it approaches the Sun a wonderful transformation takes place. The ice evaporates in the warmth of the Sun and a halo of glowing gas grows around the nucleus. This ball of gas, the coma, can swell up to 100,000km across.

Charged particles emitted by the Sun, the solar wind, push the glowing gas away from the coma to form a tail. Comet tails can stretch for millions of kilometres, always away from the Sun. The Great Comet of 1843 had a tail 330,000,000km long, more than twice the distance from Earth to the Sun. The dirty snowball becomes a heavenly ghost.

Dust particles are freed from the disappearing ice and lag behind the gas to make a second, fainter tail. A comet leaves a stream of particles in its wake. If the dust stream should cross the Earth's orbit, then our planet crashes into the particles. They burn up in our atmosphere as meteors.

Figure 2. A meteor

Billions of comets

The comets which we see are a tiny fraction of those in the Solar System. Astronomers believe that there is a huge cloud of comets - billions of them - far out beyond Pluto. This store of comets is called the Oort Cloud. The Oort Cloud is a huge spherical cloud of comets left over from the birth of the Sun's family of planets. Comets in the cloud orbit the Sun 200,000 times further away than the Earth. Most of them stay there, but some are dislodged, perhaps by a passing star. Attracted by the Sun's gravity, they begin a long journey to the centre of the Solar System and brief glory before disappearing back into the depths space. Some are deflected by planets, particularly Jupiter, to go into shorter orbits and become periodic comets.

STAR Centre

Sheffield Hallam University **Research Bulletin:** M96009

Meteor research projects - *for school groups and first-time researchers.*

Project 1. Meteor activity

Data required: Times of meteor sightings
Frequency graph (meteor numbers against time).

Meteor showers: Any meteor shower. PERSEIDS (August) and GEMINIDS (December) are recommended for first time research.

Research enquiry: Strength of meteor stream. Comparison over several nights to judge change in activity. Comparison with previous years.

Project 2. Leonid meteor shower in November

Data required: Meteor numbers and times.

Dates of observation: November 15 to 20. Peak expected on Nov 17.

Research enquiry: Every 33 years this shower is capable of turning into a storm as Comet Temple-Tuttle returns. In 1966 the rate seen in the USA was, for a few minutes, equivalent to 150,000 meteors per hour! The next storm is due in 1998 or 1999. Data is needed from now on to show whether activity is increasing.

Project 3. Christmas shooting stars

Data required: Meteor numbers and times.

Meteor showers: Ursids, December 19 - 24. Peak on Dec 23.

Research enquiry: The Ursids are a poorly observed shower and more data is needed to see how active it is. Associated with Comet Temple-Tuttle, outbursts in activity were observed in 1945 and 1986.

Project 4. A new meteor shower?

Data required: Meteor numbers and times.

Date: Around Nov 9.

Research enquiry: New meteor showers have been suspected but rarely confirmed. Most are weak showers with few meteors. In 1977 Comet P/Hartley will pass close to Earth and may even be seen with the naked eye in October 1997. Meteors from the comet might hit Earth a month later. Will we see a new meteor shower then?

STAR Centre

Sheffield Hallam University **Research Bulletin:** M96010

Meteor research projects - *for more experienced meteor researchers*

Project 5. Meteor brightness

Data required: Times of meteors.
Brightness of meteors as magnitude numbers.
Histogram of magnitude frequency.

Meteor shower: Any, particularly Perseids (August) and Geminids (December).

Research enquiry: Sizes of particles in meteor streams.

Project 6. Meteor colours, speed and brightness

Data required: Times, magnitudes, colour and relative speed of meteors.

Suitable showers: Any.

Research enquiry: Are there links between these factors?

Project 7. Plot a meteor radiant

Data required: Meteor tracks drawn on a star map.

Meteor shower: Any, but Perseids (August) and Geminids (December) are recommended. Star maps for these showers are included in the PRB.

Research enquiry: Finding the position of the meteor radiant. Finding if the radiant moves position from night to night. Finding if there are more than one radiant positions for a shower.

Project 8. Fireballs

Data required: Reports of any meteors brighter than the planet Venus (magnitude -5). Time, direction, magnitude, colour and description.

Times: Any night. Fireballs seem to be most frequent from February to April, though no-one knows why. Meteor showers with a reputation for fireballs include the Quadrantids (January), Perseids (August) and Taurids (November).

Research enquiry: large meteoroid particles, possible meteorites. These are rare events and should be reported as soon as possible.

Set 2 paper 1

Meteor Watching

by Matthew Mole

Seeing a bright 'shooting star' flash across the sky is an exciting event. A meteor watch during a meteor shower can be great fun. But sitting cold, hungry and alone in the dark with an aching neck can put you off shooting stars for ever. Some advance planning is needed if you are going to enjoy your night with the stars. After many meteor watches, here is my guide to success.

The most important thing is to observe in a group. At least three people should work together, with one acting as recorder and the others as observers (see below). As a group you have greater safety, security and are more likely to carry on through times when no meteors appear.

When to watch

Good nights are at the maximum of a meteor shower. Probably the best are the Germinids in mid-December and the Perseids in August. Try these for your first meteor watch. If it is around the time of a Full Moon, don't bother - the glare of the Moon will wash out all but the brightest meteors.

Where to observe

Find a dark site away from the glare of street lights. A dark garden is ideal. If you have to travel away from home, arrange a safe, secure place in advance and carry out your meteor watch with friends. Your local astronomical society may be able to help.

Where to look

If you are on your own you cannot spot every meteor. The best angle to look is about 50° above the horizon and about 40° away from the meteor radiant. If in doubt look towards the East.

With friends you can cover more of the sky, each looking in a different direction. The ideal number is seven - six observers and a recorder. The observers report meteor sightings to the recorder, who writes them down. The recorder changes places with an observer after an agreed time.

How long to look

An hour is the minimum time. After 2 hours take a short break. In summer you may observe for most of the night - if you can sleep the next day.

Equipment

Really only your eyes are needed! A few essentials will help make your watch successful.

Seating

Observers should lie on something warm and reasonably comfortable. A ground sheet and blanket will do, some people use a sun-lounger or air-bed. A chair is needed for the recorder.

Clothing

Lots of warm clothes are needed even in summer. Include woolly hat, gloves, extra socks and windproof coat. A rug, blanket or sleeping bag is useful.

Food and drink

A flask of hot drink and a favourite snack.

Timing

A digital watch set to accurate time using the Speaking Clock. Avoid watches with bright displays.

Clipboard and recording chart

The recorder should have a meteor form, you can copy the BAA form on the next page. Make sure that you have spare forms, pencils and pens and that the sheets of paper are securely fastened to the clipboard.

Star map

A star chart from a computer programme or a star atlas helps you to trace meteor trails and estimate their brightness.

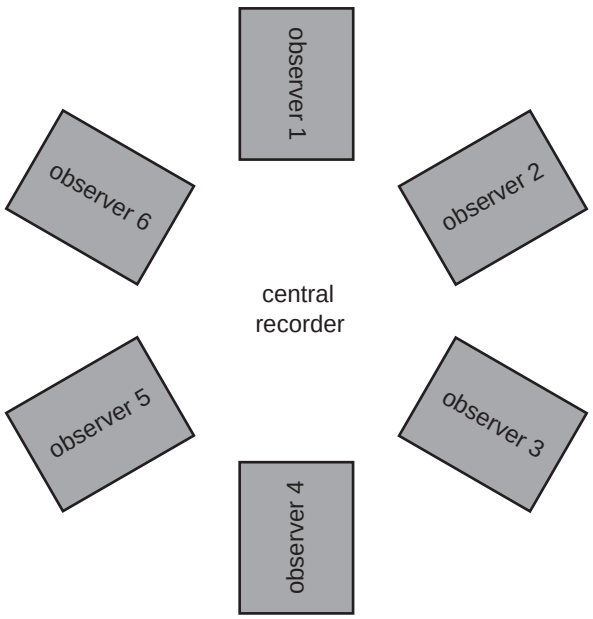


Figure 1. Suggested seating plan for observers

Set 2 paper 1 ctd

Red Flashlight

Flashlight covered in red cellophane, or a rear bike lamp. The red light will not ruin the dark adaptation of your eyes. The recorder should be in charge of the red lamp in order to record the meteors.

Peace and quiet

Neighbours do not take kindly to noises in the night, so please keep things quiet. If you want to listen to music, use earphones. Friends of mine choose mood music - Brian Eno and Enya go well with meteors.

Patience

The most important thing you can carry. Clouds may spoil the view and even on a clear night there will be long stretches of time with no meteors. Keep looking!

So enjoy the shooting stars. But a meteor watch is not only fun - it is real astronomical research.

Matthew Mole is a milkman for Warren Dairies. He says his job gives him plenty of chance to see the night sky!

Nature Research page 35 June 1995

Meteor Recording 1

Observation of meteor showers is revealing more data about the collisions of space debris with our planet. In the first of two articles Derek Pace gives a guide to recording a meteor watch.

To be of use in meteor research, observations should be carried out and recorded as accurately as possible. In this pair of articles I hope to help researchers to make a valid record of what they see. This first article covers the basic essentials and should help first-time observers to be successful.

The best way to record meteors is on a ready made form. I recommend the British Astronomical Association (BAA) Meteor Section form. It is clear and simple and is easy to use to analyse the results. A copy of the BAA form follows this article.

1. Date
Use a double date to avoid confusion. A meteor watch from the evening of December 14 to the morning of December 15, 1995 should be written as 1995 December 14 - 15.

2. Watch times
Write the start and end times of your observation. You should use Universal Time (UT), which in the UK is the same as Greenwich Mean Time (GMT). If British Summer Time is in force, subtract an hour to get Universal Time. A 24 hour system is used, so 11.30 p.m. is written as 23.30 UT.

3. Timing meteors
The time of appearance of meteors is the most important observation. Times will enable the rate of meteor activity to be assessed. Usually it is satisfactory to record the time to the nearest minute only.

4. Type
Assess whether the meteor belongs to the shower or is sporadic. Trace the path of the meteor backwards by eye. If it seems to come from the shower constellation, write the shower name (e.g. Perseid). If it does not come from the shower radiant, write sporadic.

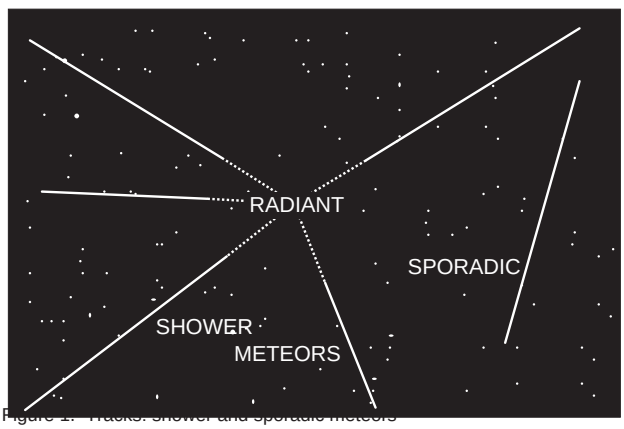


Figure 1. Tracks: shower and sporadic meteors

5. Meteor brightness
This is the measurement which frightens most first time observers, but it is a skill well worth practising. In the end it is not as difficult as it sounds. The basic idea is to find a nearby star which is the same brightness as your observed meteor. Look up the magnitude number of the star on a star chart and you have measured the brightness of the meteor.

You can use star maps printed from a computer programme with star magnitudes displayed. Meteor brightness is measured in the same way as star brightness - on a magnitude scale.

On the magnitude scale, dim stars have bigger numbers. The brighter the star, the smaller the number. The very brightest stars and planets have minus numbers. Figure 2 gives examples of magnitude numbers.

6. Constellation
Use a star map to identify the constellation in which you saw the meteor. Most shower meteors will not be seen in the constellation which contains the radiant.

7. Train
Some meteors leave a trail of light after they have gone. This glow comes from air molecules ionised by the meteor and is called a train. If you see a train, write down how long you think it lasted (usually a second or two).

8. Other details
Some meteors are coloured: yellow, green, blue and red meteors have been seen. Note down any colour.

Meteors travel at different speeds. Once you are used to seeing them you can record the speed as fast, slow or medium.

I hope that this advice will be helpful in starting your research. Believe me, it sounds more complicated than it really is. Just one meteor watch will give you the basic skills and I guarantee that you will enjoy your growing expertise. Enjoyment is the main thing in meteor watching: above all it is FUN!

Magnitude	Example of star or planet
-4	*Venus*
-2	*Jupiter*
-1	*Sirius*
0	*Capella,Arcturus,Vega,Rigel*
1	*Altair,Deneb,Aldebaran,Procyon,Regulus*
2	*Pole Star, Pointers of the Plough, Orion Belt stars*
3	
4	
5	*dimmest stars*

Figure 2 . Magnitudes of brightness

British Astronomical Association
Meteor Section VISUAL REPORT

Office Use Only	
Rec'd	Ack'd

Date 11-12/8/91 Observer Neil Bone
Observing Site Apuldram 5049'8N 0 48'3W Sheet 1 of 1
Correspondence Address "The Harepath" Mile End Lane, Apuldram Chichester, West Sussex, PO 20 7DE
Observing conditions Patchy Cirrus, 10% Stellar Lim. Mag:
Watch times Start 2150 UT End 2250 UT Duration 1hour 00m

Code No	Time U.T.	Magnitude	Name Shower or if sporadic	Constellation(s) in which seen	Train Details & time to fade (s)	Notes
1	2200	0	perseid	Peg-Aqr	1sec	Yellow/red med speed
2	2205	-3	sporadic	Aqr		long
-3	2209	1	perseid	Lyr-her	wake	yellow,fast
4	2211	-3	perseid	peg		white,fast
5	2216	2	cappacornid	Aqr		white,slow

Figure 3. A completed BAA Meteor Observation chart

British Astronomical Association
Meteor Section VISUAL REPORT

Office Use Only	
Rec'd	Ack'd

Date Observer

Observing Site Sheet of

Correspondence Address

Observing conditions Stellar Lim. Mag:

Watch times Start End Duration

Code No	Time U.T.	Magnitude	Name Shower or if sporadic	Constellation(s) in which seen	Train Details & time to fade (s)	Notes

Meteor Recording 2

Last month Derek Pace described the essentials of recording a meteor watch. In his second article he suggests ways to display and analyse your results.

You have completed your meteor watch. The meteors were exciting to see and it was an enjoyable challenge to write down your observations. Now we will see what the results mean.

1. Meteor rates - single night

Plot a graph or draw a bar chart of numbers of meteors against time.

Depending how long your watch lasted, you could split the time axis into hours or half-hours. You will be able to draw conclusions about changes in meteor activity during the watch.

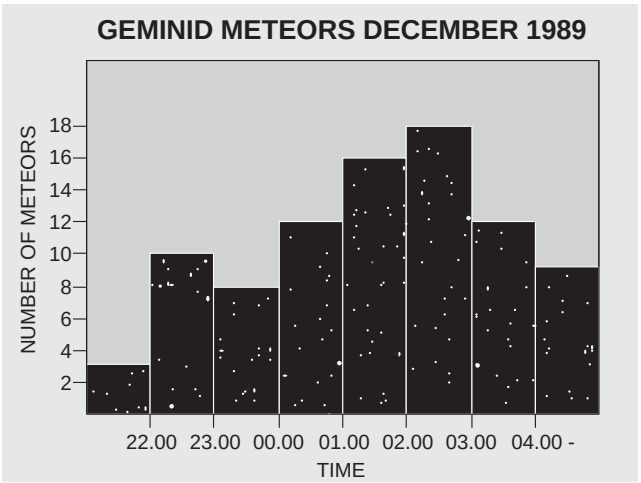


Figure 1. Geminid meteors, Dec 13 1989

2. Meteor rates - several nights

If you have recorded meteors over several nights, you can compare meteor activity on different nights. You may see activity rising to or declining from a peak.

Plot a graph of total number of meteors seen on each night against the date.

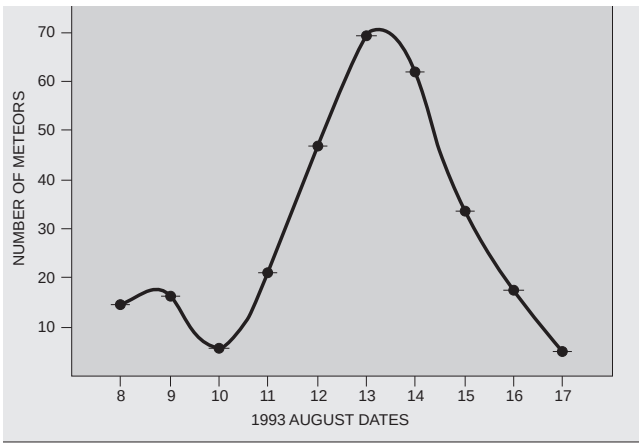


Figure 2. Perseid meteors, August 1993

3. Meteor magnitudes

The simplest analysis is to find the average magnitude of the meteors. Only use shower meteors in your first calculation. The average magnitude can be compared with other showers.

You could calculate the average magnitude for sporadic meteors and compare with the value for meteors in the shower. Which, on average, were brighter?

A more revealing method of analysis is to draw a bar chart of numbers of meteors of each magnitude number. This will show the brightness distribution and you can draw conclusions about the sizes of particles in the meteor stream, (see Figure 3, page 17).

4. Other conclusions

Your record will reveal other information about the meteor shower. You might be the first person to find some unusual aspect.

Depending on what your record contains, you could try:

- Using the 'Constellations in which seen' column and a star map to see if the meteors have a favoured direction from the radiant.
- Comparing the presence or absence of trains with the magnitude of meteors - is there a link?
- Comparing colours of meteors with magnitude - is there a link?
- Comparing magnitudes and speeds - is there a connection?

I am sure that you will think of other ways of using your results. Your analysis will help you to compare the characteristics of different meteor showers. It may also tell us about the number, size and texture of the particles of space dust which are destroyed in such a spectacular way.

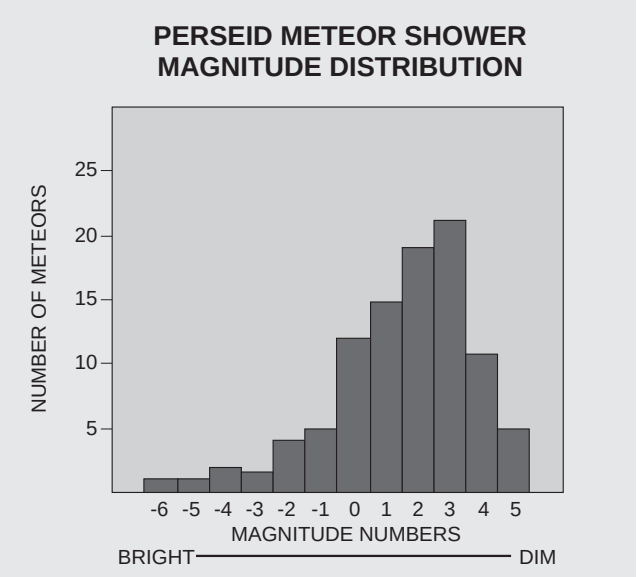


Figure 3. Perseid meteor shower, magnitude distribution

Set 2 paper 4

Map those meteors

by Sue Armishaw

Sue Armishaw shows how to find the radiants of the year's best shooting star showers.

Introduction

Meteors in a meteor shower streak across all parts of the sky. But if you trace their tracks, they all seem to come from the same point in the sky - the shower radiant. Equipped with only a pencil, a starmap and skill you can plot the radiant of a meteor shower.

Meteor dates

You will need to get hold of some skymaps showing the constellations visible in Summer and in Winter. The two maps can the be used to map:

- the Perseids (Summer sky)
  July 25 to August 20 - peak on August 12

- the Geminids (Winter sky)
  December 7 to 15 - peak on December 13.

Learning the stars

Before you try to plot meteors, you must first learn the stars and constellations in the night sky. The best way is to find a local astronomer to teach you - your local astronomical society might help. Failing this you can teach yourself using a star map. The star maps in the monthly magazines *Astronomy Now* or *Practical Astronomy* are very good.

Check the stars

Using your sky maps, make photocopies of the sky map you will use, depending on thetime of year. On skymaps south is at the bottom and the centre of the map is overhead in the sky.

Go outside on nights before the shower to check that you can match the map with the real stars. Bright stars will help you do this. For the Perseids in August, find the Summer Triangle of Vega, Deneb and Altair. For the Geminids in December find Orion.

Real research

Mapping meteors is not easy. You must learn the brighter stars and constellations, match your map with the stars then try to draw meteor trails in the dark! It is, however, real research and you might try to answer these questions:

- *is the radiant in the same position in the sky each night, or does it move from night to night?*
- *is the radiant single, or do your results show two different radiants close together?*

Plotting the meteors

Find an observing site away from the glare of street and house lights. Make sure that you are well wrapped up and do the meteor watch with friends if you can.

I hope you have clear nights and lots of meteors to draw!