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Four Perseids on a 10-minute exposure photographed by a team of the *Dutch Meteor Section* on August 11-12 from Rognes, Southern France with a Canon AV-1 (f = 50 mm, $f/1.8$). The photograph was made on Kodak Tri-X 400 ASA film which was developed in Kodak T-max during 6 minutes at 20° C. There are 50 shutter breaks per second.

In case of non-delivery, return postage guaranteed. Please return to:
v.u.: Marc Gyssens, Heerbaan 74, B-2530 Boechout, Belgium

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Contents

Useful Information

The August Issue *(WGN 22:4)*

The *August issue* is anticipated to be a thick issue and will be mailed shortly after the Perseid maximum. Contributions are due on *July 22* at the latest. They should be sent to *Marc Gyssens.*

WGN Subscription/IMO Membership 1994

The subscription rate for Volume 22 (1994) of the *Bimonthly Journal* is 25 DEM for six issues which are anticipated to contain over 250 pages in total. A combined subscription with the *Report Series* and *FIDAC News* costs 60 DEM. You can also become a Supporting Member by paying at least 15 DEM extra.

Administrative Correspondence

Ordering *IMO* publications is done in the same way as paying subscription/membership fees. Complaints about not receiving *WGN* or changes of address should be sent to *Paul Roggemans.*

All addresses can be found on the inside of the back cover.

Looking Forward to the Perseids

Marc Gyssens

Once more, the big event this summer will be the Perseids. Recent studies by Williams and Wu indicate that in 1994 , perhaps for the last time for a long while, there is a reasonable chance on another Perseid outburst, which might even be marginally stronger than the 1993 outburst. However, meteor showers remain essentially unpredictable, so we need once more the effort of all our observers to find out what will actually happen.

If a Perseid outburst recurs this year, it is most likely America that will benefit. Therefore, we especially call upon all American observers to monitor Perseid activity closely and accurately. As the IMO *is not interested solely in activity outbursts, but also in the entire activity profile,* all *observers should watch the Perseids, particularly in the days and hours before and after the time of a possible outburst.*

As happened last year, the IMO *will make an effort to produce a first report on the 1994 Perseid activity within hours after dawn in California on August 12. The coordination center will be set up in London, Ontario, Canada and will be run by Peter Brown. Please provide him and his collaborators with your findings! Also, non-American observers are encouraged to provide Peter with information about their observations, especially from shortly before to shortly after the period of a possible outburst. Information on how to communicate with Peter can be found elsewhere in this issue.*

Our experience from last year taught us that it is indeed possible to compose a reliable report on shower activity very soon after the event. While the picture the IMO *presented in its first press release on the 1993 Perseid activity was generally correct, the activity observed in North-America was generally over-estimated. The reason for this is that many North-American observers reported impressions rather than hard data. As this year American observers will be mainly responsible for the most interesting part of the Perseid activity profile, we urge all observers to report exact data to Peter so that our first 1994 press release will be at least as reliable as the one last year! Again, instructions can be found elsewhere in this issue.*

Due to time limitations on my part, it was not possible to prepare a thick June issue. Consequently, this issue is almost entirely devoted to the Perseids. Please read all this information attentively. It will help you and us to get the most out of your observations!

Apart from information on Perseids and other regular items we have one main article in this issue on sporadic activity in the period 1934–1943 as observed from Přerov in what is now the Czech Republic. It is of interest to note that, before submitting the article to WGN*, the author solicited Professor Kresák's opinion. Professor Kresák thought highly about this article for the following reasons:* (i) *the observations were carried out during a period for which there exist relatively few observations;* (ii) *the observations cover the 10-year period in a very homogeneous way; and* (iii) *the observations are reduced statistically at an unusually high level. Professor Kresák expressed this opinion in a letter to the author dated January 17—just three days before his unexpected death. Partly in honor of Professor Kresák, we decided to give this article priority and publish it in the June issue. At the same time, we hope to be of service to the meteor community by disseminating this valuable series of observations from a period when most of us were not even born.*

The August issue will again be a thick issue in which we will eliminate our back log. It is scheduled to appear very shortly after the Perseid maximum and will contain, as an addendum, a polished version of the press releases the IMO *issued concerning the peak activity of the Perseids.* IMO *members will also find the 1995* Meteor Shower Calendar *included. Meanwhile, enjoy this issue and enjoy the Perseids and the other summer showers!*

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

What magnitude does a meteor have to reach to be a fireball?

There is no natural distinction between fireballs and ordinary meteors. Therefore, it is purely a definition when we say that a fireball is a meteor of magnitude −4 or brighter. If you observe such a bright meteor, please report this to the *Fireball Data Center (FIDAC)* of the *IMO* which stores each fireball in a database. The next paragraph deals with estimating a fireball's magnitude. As the estimates will be somewhat uncertain, the *FIDAC* also stores meteors which were estimated to be of magnitude −3. If you see such a "semi-fireball" you should also send the relevant data to the *FIDAC*.

How can I estimate the brightness of a fireball?

Meteors with brightnesses up to magnitude 0 can be estimated with sufficient accuracy. When it comes to events with negative magnitudes, the observer will not have enough reference objects. Sirius (α CMa) has a magnitude of approximately −1.5, but is a good reference star for observers on the southern hemisphere only. There are also the planets which have the disadvantage that their brightness changes depending on the position to the Earth. Jupiter has magnitude −2.2 at brightest, we may assume its brightness to be about −2 until July, 1994. The planet is visible in Libra during the summer. Venus can be brighter than magnitude −4; however it is of magnitude −3.5 until July, 1994 before reaching maximum elongation. During dawn visibility in December, 1993 (remember the Geminids), Venus was of magnitude −4.4.

Objects brighter than Venus will rarely, if ever, be present when you observe as moonlight generally causes you not to observe. Hence, you have to extrapolate the brightness from visible objects or from well-known impressions like that of Venus or the Moon, though they may not be visible. The scale of astronomical magnitudes is logarithmic. Note that a fireball that emits twice as much light as a visible object exceeds the latter by less than one magnitude. An object being 4 magnitudes brighter than a reference object produces 40 times more light.

As bright fireballs usually illuminate the surroundings, try to remember whether the meteor cast shadows. If so, the fireball was at least magnitude −5. If you see a fireball directly in the center of the retina consider the effect of blinding at this point. When the fireball vanishes try to perceive stars in the very center of the retina. If you cannot even see magnitude +2 stars, the meteor was likely near magnitude −10.

What does the "k" column mean in the Moon phase table of the Observers' Notes?

This column gives the percentage of the Moon that is illuminated. A value of 0.86 means that 86% of the visible disk of the Moon is illuminated by the Sun. The measure k assumes that the Moon is a disk, not a sphere. A "+" behind the k-value means that the Moon is waxing, a "−" indicates that it is waning. For observing, k should be no larger than 0.30 when the Moon is above the horizon, except when something interesting is expected, such as the maximum of a major meteor shower.

Visual Observers' Notes: July–August 1994

Jeff Wood and Marc Gyssens

1. Introduction

The period July–August is the most consistently rich period for meteor rates of the whole year. On a dark night an observer can expect to see over 20 meteors per hour for much of this time. During the last few days of July and around August 12 with the maxima of the major showers the δ-Aquarids and the Perseids, respectively, the total number of meteors exceeds 50 per hour and rates much higher than this are not uncommon. The Perseid outburst recorded the last few years and studied by Williams and Wu [1,2] adds to the excitement surrounding this year's Perseid return. With all this activity, meteor workers are encouraged to get out and observe the many showers that occur. Table 1 lists the more important showers that occur during July and August. Table 2 shows the observing conditions moon-wise.

Table 1 – A list of some of the meteor showers to be seen in July–August 1994.

Shower	Activity	Maximum		Radiant			Drift		V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	D.	$\Delta\alpha$	$\Delta\delta$			
Pegasids	Jul 07–Jul 11	Jul 09	107°7	340°	+15°	5°	+0°8	+0°2	70	3.0	8
Phoenicids (Jul)	Jun 24–Jul 18	Jul 15	112°7	21°	−43°	7°	+1°0	+0°2	47	3.0	
Piscis Austrinids	Jul 09–Aug 17	Jul 28	125°7	341°	−30°	5°	+1°0	+0°2	35	3.2	8
δ-Aquarids S	Jul 08–Aug 19	Jul 28	125°7	339°	−16°	5°	Table 3		41	3.2	20
α-Capricornids	Jul 03–Aug 25	Jul 29	126°7	307°	−10°	8°	Table 3		23	2.5	8
ι-Aquarids S	Jul 15–Aug 25	Aug 03	131°7	333°	−15°	5°	Table 3		34	2.9	3
δ-Aquarids N	Jul 15–Aug 25	Aug 12	139°7	337°	−05°	5°	Table 3		42	3.4	5
Perseids	Jul 17–Aug 24	Aug 12	139°9	46°	+58°	5°	Table 3		59	2.6	95
κ-Cygnids	Aug 03–Aug 31	Aug 18	145°7	286°	+59°	6°			25	3.0	5
ι-Aquarids N	Aug 11–Sep 20	Aug 20	147°7	327°	−06°	5°	Table 3		31	3.2	3
π-Eridanids	Aug 20–Sep 05	Aug 29	155°7	52°	−15°	6°	+0°8	+0°2	59	2.8	
α-Aurigids	Aug 24–Sep 05	Sep 01	158°6	84°	+42°	5°	+1°1	0°0	66	2.5	15
Piscids S	Aug 15–Oct 14	Sep 20	177°7	8°	00°	8°	+0°9	+0°2	26	3.0	3

Table 2 – Moonlight and observing conditions in July–August 1994.

Date	*k*	Date	*k*
Friday July 01	0.48–	Friday August 05	0.06–
Friday July 08	0.01–	Friday August 12	0.25+
Friday July 15	0.38+	Friday August 19	0.94+
Friday July 22	0.99+	Friday August 26	0.79–
Friday July 29	0.64–	Friday September 02	0.17–

New Moon:	July 8, August 7, September 5
First Quarter:	July 16, August 14, September 12
Full Moon:	June 23, July 22, August 21
Last Quarter:	June 30, July 30, August 29

2. Perseids

This shower is active from July 17 to August 24 and traditionally reaches a maximum ZHR of about 95 on August 12 or 13. With New Moon on August 7, observing conditions are mostly favorable, except for the very end of the activity period. As the radiant has a high declination, the Perseids are best studied from the northern hemisphere.

In 1992, the Perseids had an outburst with several hundreds of meteors per hour witnessed in Asia and Eastern Europe. [3] The year 1992 was the second of two consecutive years in which an outburst was seen, about 12 hours before the "traditional" Perseid maximum. [4] This double maximum was first registered in 1988 after which it became ever more obvious. Shortly after the 1992 outburst, Comet P/Swift-Tuttle was finally rediscovered. As the presence of the parent comet had now become the most likely explanation for the outbursts, another outburst was expected in 1993. This outburst did indeed occur, though it was probably less spectacular than the previous ones [5]. Work by Williams and Wu [1,2] suggests the possibility of another outburst in 1994, which may even be stronger than the 1993 activity spike.

America is most favorably placed to see this possible outburst during their night of August 11-12, 1994. To obtain a clear picture of what will actually happen, it is important to have many, reliable observations. It is also important that especially the observers in America communicate their findings to the *IMO immediately* after the event so that we can forward reliable information to astronomical institutions and the media.

Following the general information for visual, radio, and telescopic observers is a general article by Peter Brown, coordinator of this year's fast-reporting network, on what to expect from the 1994 Perseids, on how to observe them, and on how to report the observations. This article is followed by more specific instructions on how to observe the 1994 Perseids visually, photographically and by video, by radio, and telescopically. Please take full advantage of all this information supplied to you so that we and you can get the maximum possible out of your observations!

Finally, this issue has a leaflet enclosed with general information on the Perseids, their recent behavior, and the prospects for a 1994 outburst which you are free to use in raising awareness of the event for the general public and the press in your region of the world.

3. Aquarids/Capricornids

This rather complex group of showers were subject to intense scrutiny during 1989 to 1991. Several thousand meteors were recorded. Nevertheless, more data on this poorly covered complex are still required. The visual observing program requires good observational experience and an observing site south of 45° N. Looking at Table 3, it is obvious that the observer has to look at a point between the radiants of the δ-Aquarids N and the ι-Aquarids S in order to distinguish between meteors of these southern showers. This will be quite impossible for observers situated north of 45° N. Observations of this program should start only when the radiants have reached a sufficient altitude. If possible, two observers should look at the same field simultaneously. This may allow estimates of the accuracy of the data. Only meteors possibly radiating from the Aquarius/Capricornus-region should be plotted. It is necessary to consider the direction, trail length and angular velocity. All other meteors are counted only. Any Aquarids or Capricornids appearing outside the map's field are also counted after they are associated with the radiants given in Table 3.

In doing so, we are able to calculate ZHRs based on the tabulated radiant positions, and to analyze the radiant position using the plotted meteor trails only. We want to draw attention to the relationship between the angular velocity of shower meteors, the altitude of their beginning point h_b and the distance D between their end point and their radiant. This criterion is as important as the alignment and the trail length and has to be used carefully when using the counting method. The relationship between these quantities has last been published in [6].

Your reports must include the following for each date:

1. copies of your *Atlas Brno* maps with the meteors plotted on them (X and Y coordinates should be measured with respect to the frame of the map), and
2. a report using the *IMO* Visual Observing Forms.

The shower association should be done at a desk using all criteria, including path length, position with respect to the radiant and angular velocity. For more details, we refer the reader to [7].

Table 3 – Radiant drifts for the α-Capricornids, the δ-Aquarids South and North, the ι-Aquarids South and North, and the Perseids.

Date	α-Cap		δ-Aqr S		δ-Aqr N		ι-Aqr S		ι-Aqr N		Per	
	α	δ	α	δ	α	δ	α	δ	α	δ	α	δ
Jul 05	290°	−14°	321°	−21°								
15	296°	−13°	329°	−19°	316°	−10°	311°	−18°			12°	+51°
25	303°	−11°	337°	−17°	323°	−09°	322°	−17°			23°	+54°
Aug 05	312°	−09°	345°	−14°	332°	−06°	334°	−15°			37°	+57°
15	318°	−06°	352°	−12°	339°	−04°	345°	−13°	322°	−07°	50°	+59°
25	324°	−04°			347°	−02°	355°	−11°	332°	−05°	65°	+60°
Sep 05									343°	−03°		
15									353°	−02°		

4. κ-Cygnids

This shower is active from August 3 through to August 31 and reaches a maximum ZHR of 5 on August 18. The radiant position of $\alpha = 286°$ and $\delta = +59°$ is virtually constant throughout the activity period due to its proximity to the North Ecliptic Pole. Its diameter is 6°. Unfortunately, the Moon will seriously interfere during the maximum of this shower. The κ-Cygnids are noted for their slow-moving often bright meteors. All possible shower members should be plotted. Observers should ensure that the center of their observing field is located at a distance less than 40° from the radiant.

5. July Phoenicids

The July Phoenicids are fairly fast, faint meteors which is probably the reason why they were first detected by radio techniques. Since this stream can only be observed from the southern hemisphere where it is winter, it has not been very well monitored to date. As the July Phoenicids are well placed for viewing moon-wise in 1994 for a substantial part of their activity period, southern hemisphere observers are therefore encouraged to make this a special project.

6. Piscis Austrinids

The Piscis Austrinids are active from July 9 to August 17 and reach a maximum ZHR of 5 to 10 meteors per hour on July 28. Unfortunately, the Moon interferes heavily with the maximum of this shower. Observers should concentrate on the early and late activity of this shower which they can do as part of their Aquarid/Capricornids observations. They should plot all Piscis Austrinids occurring in the part of the sky covered by the map and count those appearing outside the map's field after careful consideration of path length and angular velocities.

Table 4 – Radiant positions of the Piscis Austrinids.

Date	α	δ	Date	α	δ	Date	α	δ
Jul 13	326°	−33°	Jul 28	341°	−30°	Aug 12	356°	−27°
Jul 18	331°	−32°	Aug 02	346°	−29°	Aug 17	1°	−26°
Jul 23	336°	−31°	Aug 07	351°	−28°			

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[1] Z. Wu, I.P. Williams, "The Perseid Meteor Shower at the Current Time", *Mon. Not. R. Astron. Soc.* 264, 1993, pp. 980–990.

[2] I.P. Williams, Z. Wu, "The Current Perseid Meteor Shower", *Mon. Not. R. Astron. Soc.*, 1994, to appear.

[3] P. Brown, M. Gyssens, J. Rendtel, "New Outburst Announces Return of P/Swift-Tuttle", *WGN* 20:5, October 1992, pp. 192–197.

[4] R. Koschack, R. Arlt, J. Rendtel, "Global Analysis of the 1991 and 1992 Perseids", *WGN* 21:3, June 1993, pp. 152–167.

[5] J. Rendtel, "Perseids 1993: A First Analysis of Global Data", *WGN* 21:5, October 1993, pp. 235–239.

[6] J. Wood, "Visual Observers' Notes: May–June 1994", *WGN* 22:2, April 1994, Table 5, p. 33.

[7] R. Koschack, J. Rendtel, "Aquarid Project 1989", *WGN* 17:3, June 1989, pp. 90–92.

Theoretical Radiants of Minor Planets and Comets

Dirk Artoos

Table 1 – Theoretical Radiants of Asteroids and Comets in July–August 1994.

Name	$\lambda_\odot$	Date	α	δ	V_∞	Distance
1988 XB (5748)	97°66	Jun 29	270°2	−16°	17.3 km/s	0.02282 AU
1986 LA (3988)	100°12	Jul 02	255°5	−73°5	13.6 km/s	0.18565 AU
Adonis (2101)	106°27	Jul 08	296°5	−22°7	27.3 km/s	0.02148 AU
1994 AW1	110°97	Jul 13	60°4	−65°4	17 km/s	0.03602 AU
1986 TO (3753)	115°31	Jul 18	91°5	+50°7	21.3 km/s	0.07921 AU
Aten (2062)	118°03	Jul 20	221°6	+63°6	16.7 km/s	0.07921 AU
P/1987 III	118°5	Jul 21	35°6	+19°	72 km/s	0.117 AU
1994 BC	126°25	Jul 29	97°3	−43°2	15 km/s	0.06899 AU
1994 CN2	133°66	Aug 06	275°4	−16°6	13.3 km/s	0.01427 AU
1982 BB (3103)	138°21	Aug 11	307°9	+35°3	18 km/s	0.0887 AU
Toro (1685)	141°33	Aug 14	330°6	−35°9	17.5 km/s	0.12425 AU
P/1985 III	144°1	Aug 17	328°8	−18°	27 km/s	0.06015 AU
Khufu (3362)	147°30	Aug 20	138°6	+34°1	18.8 km/s	0.01733 AU
1988 EG (5640)	148°78	Aug 22	330°9	− 4°8	19 km/s	0.0338 AU
Asclepius (4581)	149°54	Aug 22	334°4	+ 2°8	16 km/s	0.04504 AU
1989 FC (5804)	148°83	Aug 22	333°7	+ 2°6	16 km/s	0.04514 AU
Ra-Shalom (2100)	150°8	Aug 24	93°	+52°	17 km/s	0.17896 AU
Castalia (4769)	153°76	Aug 27	354°	−19°3	19 km/s	0.02250 AU
1987 SY (5542)	157°51	Aug 30	153°7	+ 1°4	21.3 km/s	0.04263 AU
Pan (4450)	158°2	Aug 31	154°3	+ 1°1	21.3 km/s	0.04257 AU

Telescopic Observers' Notes: July–August 1994

Malcolm J. Currie

The main meteor season will soon be with us, and naturally excitement surrounding the *Perseids* will again enhance interest in meteors. For the telescopic observer, it is the radiant structure that is of most interest, as the Perseids are relatively deficient in small particles. Over the years a number of sub-radiants have been seen—many by telescopic methods—around the shower's maximum. Hitherto these telescopic sub-centers have been recorded by only one or two observers, presumably because of the attraction of the visual show. I hope that in 1994 all telescopic observers will concentrate on this shower during the week August 10–16. Those too far north to investigate the ecliptic complex are also encouraged to monitor the Perseids and the other minor showers in the proximity [1,2] before August 10. Further details on the observing method and what to do should Perseid rates climb well above expectations are given elsewhere in this issue. Last year's campaign with a small number of meteors showed what is possible. Let us consolidate upon that in 1994.

The other major interest at this time of year is the concentration of radiants clustered in Aquarius, Capricornus, and Sagittarius. All but the α-Capricornids are rich in faint meteors. The Commission has been accumulating a data set for the *Aquarid-Capricornid* Complex since 1988 for a global analysis using RADIANT. The aims are to see which of the apparent radiants are present every year, those which are ephemeral, and those which are due to chance alignments. For the annual showers we may also be able to determine radiant motion and estimate duration. To that end, I have been measuring all *IMO* observations relevant to these showers. Given a reasonable sample in 1994 that analysis can begin. Already from crude analyses the complexity of the region is apparent. A strong (and when found in 1989 unexpected) Sagittarid radiant is present in late July and early August.

For the southern showers it is important to plot each meteor's path and estimate its speed as carefully as possible. This will increase the signal to noise. It is also vital to use several field centers; only if a radiant is seen from at least three locations and by different observers (and yields sufficient number of meteors) can we be confident about its reality. Multiple fields reduces the problems introduced by radiant occlusions. The magnification of meteor angular speeds calls for observing centers that are closer to the radiants. Besides reducing the contribution of orientation errors, this geometry means that not all the paths are oriented nearly north-south as might be the case for those located north of 40° N; this makes pinpointing of the radiants' declinations more reliable too. Nevertheless observations from those located south of latitude 40° N are especially welcome not only because of the higher rates resulting from the complex's higher elevation, but also the ability to observe from the east or west of the radiants. Those north of 40° N should use chart numbers (west to east) 150, 133, 136/151, 137, 152, 138/153, and 139; and those south of that latitude use charts 161, 162, 151, 163, 152, and 153. If there is much interest from observers south of 30° N, I shall add extend the chart set further south to give some fields around $\delta = -12°$. Observations can be made in mid-July, which can cover the embers of the Ophiuchid-Sagittarid complex too, and then during August 3–10.

While investigating the southern showers, you can monitor and detect northern minor showers. For example, in 1989, a pronounced radiant was detected near τ-Cygni around $\lambda_\odot = 132°$. Others include the *κ-Cygnids* and the *η-Aquilids.*

During July's dark time, the *Pegasids* have little telescopic observations possibly due to their very high speed and post-midnight sessions are needed for highest rates. Given the high angular speed the field centers are placed close to the radiant. At present, there is no ideal pair of charts. Charts 116 and 153 are probably best, though 116 is rather close to the radiant. An alternative set are 115, 152, and 164. These are about 16°–20° from the radiant. We should be able to determine the radiant's location and diameter.

Before midnight and after July 11, efforts should be directed at the *α-Lyrids* and the *o-Draconids.* These both give weak activity though that has not always been the case for the former shower. At its discovery in 1958, the α-Lyrids were easily the strongest telescopic shower of the year around three times the sporadic rate. Since then, it has waned by an order of magnitude. However, it may be a phoenix and will return periodically to its former prominence. For that reason, it is always worthwhile to monitor this shower. The radiant is still the compact 2° as first observed. Its meteors are fast. The approximate activity period is July 9–20. The o-Draconids offer a very weak visual shower; however, the telescopic shower does give a measurable flux around 0.3 of the sporadics from $\alpha = 276°$, $\delta = +62°$. Activity may be concentrated at $\lambda_\odot \approx 114°$. Use charts 47, 69, and 70 for both showers. Chart 47 is too close to the o-Draconid radiant, but it is needed to obtain a reliable right ascension of an α-Lyrid radiant displaced several degrees north of its original declination, as was observed in 1989 and 1990. This displacement and the shower's decay may be connected.

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[1] V. Znojil, "Telescopic Meteor Showers of the Summer Season", *WGN* 18:1, February 1990, pp.19–24.

[2] M.J. Currie, "Telescopic Results near the 1993 Perseids' Maximum", *WGN* 22:2, April 1994, pp.37–46.

The IMO 1994 Perseid Effort

P. Brown

1. Overview of the prediction for the Perseids in 1994

As in 1993, the *IMO* is preparing a special observational effort for the possible strong return of the Perseids this year. While few now believe that a meteor storm will materialize, the chance that high rates akin to the 1993 outburst will occur is quite probable. Recent theoretical models [1,2] suggest that the Earth will encounter new material from P/Swift-Tuttle in 1994 in much the same fashion as the past few years. If these predictions are born out, meteor observers stand a good chance of witnessing a spectacular meteor display.

As lunar conditions are much more favorable this year than last, the impression most will have of the shower should be concomitantly better. The time the Earth crosses P/Swift-Tuttle's node in 1994 is near 7^h30^m UT on August 12. Based on the past few years' performance, the peak activity can be expected several hours after this time, probably near 10^h UT, though a range of peak times from 8^h–12^h UT (or so) are entirely possible. This timing will mean that North America will be the favored location to see any outburst that should occur; the West Coast, in particular, will almost certainly be witness to any increased activity. Those on the East Coast may get to see the beginning of the rise in rates, and perhaps the peak under twilight conditions, with the radiant high overhead. Japanese observers may also see some of the outburst shortly after sunset in the early evening hours. Occurring on a Thursday evening, the outburst, should it occur, will be backed up some twelve hours later by the regular Perseid peak conveniently falling on a Friday evening under moonless skies when European observers can best watch the display. The increased scrutiny and number of observers from North America and the usual large numbers of observers in Europe in August should combine to make the 1994 Perseid shower the most intensely monitored visual meteor display yet by the *IMO*.

2. The IMO's 1994 Perseid Campaign

In anticipation of the large numbers of observers who will watch the display and the possible recurrence of the intense media interest in the shower as in 1993, the *IMO* will once again establish a fast communication network for coordination of Perseid data. The main *IMO* Perseid data center in 1994 will be in London, Ontario, Canada, at the Department of Physics of the University of Western Ontario (see contact numbers below). The aim of this center will be to provide astronomical organizations and interested media outlets with a picture of the stream's activity shortly after any outburst has occurred. In addition, the center will endeavor to provide accurate information concerning the shower to the media and the public prior to the peak and in so doing produce another "positive" meteor shower experience.

To do this, we need to acquire quickly Perseid observations from the night of the outburst. Starting at 11^h UT on August 12, the center will be manned and we ask that you forward your observations as soon as possible for inclusion in the preliminary results. Prior to 11^h UT you may also call and leave a voice-mail message with the essential data (see below), fax your observations, or send an electronic-mail message to the center. While real-time monitoring of the shower will not be performed as last year, we do hope that near real-time assessment of the activity can be made. As such, we ask that you try to send in your transcribed data as soon as possible after you have finished observing. However, as you send your visual observations, they must contain some essential data:

1. your name and location;
2. a break-down of the number of Perseids and non-Perseids during (minimum!) 1-hour (smaller intervals are much preferred if activity is high) time intervals; and
3. sky conditions (limiting magnitude, effective observing time, and cloud cover) for each interval above.

Optionally, magnitude data can be given, but at a later time if you have not been able to transcribe this for your first reporting. If you do not fully report all your data during this initial communication, please be sure to follow-up with a written copy of your observations sent to the *IMO* in the usual way. Also, radio observers may communicate their preliminary observations according to the method described further on in this issue. If all works according to plan, a first look at the shower's activity should be complete within 12 hours of the peak and the initial results sent out with the next *WGN*.

1994 IMO Perseid Data Center
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References

[1] I.P. Williams, Z. Wu, "The Current Perseid Meteor Shower", *Mon. Not. R. Astron. Soc.*, 1994, to appear.
[2] J. Jones, P. Brown, M. Beech, "Predictions for Enhanced Perseid Activity over the Next Few Decades", abstract to be presented at the *Meteoroids Symposium* to be held in Bratislava, August 23–31, 1994.

Hints for Visual Observations of the Perseids

Rainer Arlt

1. Retrospect

An impressive number of observers monitored the maximum of the Perseid meteor shower in 1993. It was no doubt the best observed major shower maximum ever registered by the *IMO*. Theoretical predictions promise high activity for 1994 as well. Peak rates should be comparable to 1993. Meanwhile, the majority of observations from the 1993 return have been entered into the *Visual Meteor DataBase (VMDB)*. We expect the total of Perseids meteors seen in this period to total around 80 000. However, magnitude estimates were made for only 50 000 of the meteors, although magnitudes are essential data of a meteor. Several inadequacies concerning both the observing method and the utilization of the observational data occurred during the input work which might be improved for the next Perseid event. On a few occasions, I was able to reconstruct the information missing from the meteor lists. This effort, however, took a considerable amount of time. In many reports, detailed information on the Perseid peak was lost due to an improper breakdown of the observations.

2. What is expected

The time of the primary peak probably coincides with the dark hours of American longitudes on August 11-12. Observers should be prepared for very high activity lasting for a few hours. There is little reliability on rate predictions, but peak activity might be at least as high as in 1993. The traditional maximum occurs roughly half a day later, during the night August 12-13 for European observers. Watches on the night of August 11-12 will probably show increasing activity towards the young peak, but they will not show extra-ordinary rates in Europe. Do not forget that an August 12-13 observation will impress European observers with the high activity of the traditional maximum, which is still of interest.

3. The observation

The observing methods for very high activity were given in [1]. Let me summarize the main items regarding visual observations during the peak activity period. As meteors will appear very frequently, do not record a variety of data to each meteor. The essential information of a meteor is the shower association (shower/non-shower) and its magnitude. Do not record the time of each individual meteor for counting purposes. Since there will be too little time to reliably make minor showers associations during the event, just count all non-Perseids as sporadics.

The meteors will be so numerous that magnitude distributions will be smooth, even if you estimate whole magnitudes only. On the other hand, do not make the opposite error by accumulating meteors of certain magnitudes only. Try not to lose your sensitivity for differences in brightness. With high activity, we have the unique opportunity to investigate short-term fluctuations of the meteor stream: 15–20 meteors are a reliable statistical sample. These small numbers of meteors will appear in a few minutes during the maximum night. Note that you should not forget to record enough time stamps between the meteors. Moreover, it is not essential that intervals are chosen at certain "rounded" times, such as 1^h00^m–1^h30^m. Feel free to use your relatively regular time stamps to divide the observation into intervals. These times may be, e.g., 2^h00^m, 2^h11^m, 2^h20^m, 2^h29^m, 2^h35^m, 2^h42^m, and 2^h50^m. Several observers encountered problems with noting down the meteors as there was very little time available for each meteor. If you intend to use a tape recorder, just say the whole magnitudes to the tape and mention the shower only if it was other than the Perseids (so say, e.g., *four, zero, one, sporadic two, three, minus two*). Alternatively, my personal method might be used whereby I write on paper rolls without actually seeing the paper (the sort of rolls which are used in shops to produce cash register receipts work well) and easily get up to 5 meteors on one line just by writing something like, `4 0 1 S2 3 -2`. Figure 1 shows how to hold the roll and what the result may look like.

During high activity (observed rates above 100 per hour), observe the following guidelines:

- distinguish shower/non-shower only;
- estimate whole magnitudes; and
- record time stamps at least every 15 minutes or, even better, every 10 minutes.

4. The observing form

It is a general recommendation in the *IMO*'s observing method to split observations into periods which should not be shorter than 1 hour. This rule cannot hold for high activity observations. The background of the one-hour limit is to ensure that the period contains a reasonable sample of meteors.

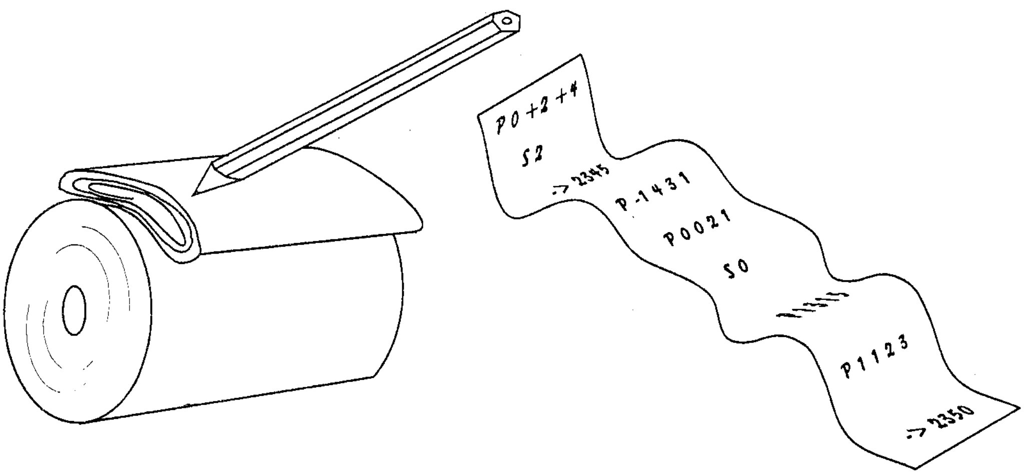

Figure 1 – A fast and convenient method to record high meteor rates. The observer writes onto a paper roll blindly.

Date: 1994 Aug 12
Observer: X. Ample
Location: Somewhere $\lambda = 10°20'$ W $\varphi = 40°50'$ N

Observed Showers: Perseids at $\alpha = 46°$ $\delta = 58°$, non-Perseids

Period	Field α,δ	T_{eff}	F	lm	PER	Spor
0105-0115	20 30	0.17	1	6.02	19	3
0115-0125	20 30	0.17	1	6.05	21	2
0125-0135	30 30	0.17	1	6.05	25	3
0135-0145	30 30	0.17	1	6.05	31	4
0145-0157	40 30	0.20	1	6.05	30	2
Break 0157-0205						
0205-0210	40 40	0.08	1	6.10	17	0
0210-0215	40 40	0.08	1	6.10	16	2
0215-0219	40 40	0.07	1	6.10	16	2
0219-0225	40 40	0.10	1	6.10	19	1
0225-0230	50 40	0.08	1.05	6.00	12	0
0230-0245	50 40	0.25	1.10	5.98	13	3
0245-0300	50 40	0.25	1.15	5.90	11	1
Break 0300-0334 (clouds)						
0334-0345	60 70	0.18	1	6.15	21	3
0345-0350	60 70	0.08	1	6.15	19	1
0350-0355	60 70	0.08	1	6.15	25	0
0355-0400	60 70	0.08	1	6.15	26	1
0400-0405	60 70	0.08	1	6.00	24	0
0405-0410	60 70	0.08	1	5.80	23	2
0410-0415 (dawn)	60 70	0.08	1	5.50	18	0

Magnitude distributions:

Shower	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	tot
PER 0105-0135	-	1	1	-	2	3	8	13	14	10	9	3	1	-	65
PER 0135-0157	-	-	-	1	-	1	3	15	15	16	8	2	-	-	61
PER 0205-0219	1	-	-	-	1	2	1	7	10	11	9	5	2	-	49
PER 0219-0300	-	-	2	1	-	2	10	11	8	8	7	5	1	-	55
PER 0334-0405	-	1	1	2	2	4	12	19	23	10	10	7	-	-	91
PER 0405-0415	-	2	2	-	1	7	11	12	11	10	7	2	-	-	65
Spor	-	-	-	-	1	-	1	3	2	6	10	5	2	-	30

Figure 2 – An example of a Perseid maximum night report. Note how the breakdown of intervals was done.

During the maximum of the Perseids, there will be plenty of meteors. Expecting 10 times more meteors than usual you can also define periods being ten times shorter than in nights of normal activity. If the apparent activity exceeds 50 meteors per hour, half-hour periods are the upper limit. Breakdowns into quarter-hour periods are welcome unless they contain less than 10 meteors. On the other hand, periods can be as short as 5 minutes for an activity around or exceeding 200 meteors per hour. Please report both Perseid and non-Perseid numbers for each interval although there might be very few non-Perseids in a 5-minute period.

Moreover, short-term changes in the population index r can be detected by appropriate magnitude distributions. Please report several Perseid magnitude distributions for the maximum nights. A typical magnitude distribution should contain about 40–60 meteors. Hence, the periods will be half an hour or one hour long. For convenience in the analysis, use the same time stamps you used for the breakdown of the reported meteor numbers. You should always remember that too short periods can easily be combined to more reasonable ones, whereas too long intervals cause a loss of information. To ensure that the best is made out of your observation, enclose a complete meteor list to your report. You will probably have to write down the list once when you listen to your tape anyway, so just make a copy of it and send it to the Commission Director.

To summarize, observe the following guidelines when preparing your Perseid report:

- When the activity is about 50 meteors per hour, report Perseid and non-Perseid numbers for 15-minute periods. Give magnitude distributions per period of about 1 hour.
- When the activity is about 100 meteors per hour, report Perseid and non-Perseid numbers for 10-minute periods. Give magnitude distributions per period of about half an hour.
- When the activity is about 200 meteors per hour or higher, report Perseid and non-Perseid numbers for 5-minute periods. Give magnitude distributions per period of about 15 minutes.
- Enclose a meteor list with the time stamps of the night.

Figure 2 shows an example of a complete meteor report. I did not use the standard Report Form as there might be too little space for detailed interval data. Completeness has definitely priority over the format. Note the variable interval length and split magnitude distributions. Reports should be sent to the *Visual Meteor DataBase, c/o Rainer Arlt, IMO Visual Commission Director, Berliner Straße 41, D-14467 Potsdam, Germany.*

Photographic and Video Observations During the Perseid Peaks

Jürgen Rendtel

1. Photographic work

There are very few occasions when the number of visible meteors exceeds a level of about 100 per hour. Visual observers cannot accurately record such events. As well, radio techniques may have problems with recording this phenomenon due to saturation effects caused by the superposition of signals from many meteor trails simultaneously. Photographic and video observations are appropriate techniques under these circumstances.

For the investigation of the meteor stream involved in such events, it is very important that reliable magnitude data are obtained as well as precise numbers of meteors per time unit. Because of the factors involved in the ability of a lens-film combination to photograph meteors of different angular velocity and brightness, there are several, mainly geometrical reasons, which make this task more difficult:

- shower meteors move faster the closer one gets to 90° distance from the radiant;
- shower meteors move faster near the zenith than near the horizon; and
- the film will record fainter meteors of low angular velocity, or only bright meteors of high angular velocity.

Of course, there is no possible camera field which is not affected by these factors. But we may minimize their influence.

The camera should be pointed 180° away from the radiant in azimuth. If a wide angle lens is used, the lower limit of the field should be 10°–20° above horizon. For a standard lens of $f = 50$ mm the elevation of the optimum field center depends on the elevation of the radiant $h_{\rm rad}$. The most suitable elevation of the field center $h_{\rm fc}$ is given in Table 1.

At a mid-northern latitude of $\varphi = 45°$ the respective data are listed in Table 2. For most of the night you may direct your camera (with a standard lens) to the southwestern sky centered at about 60° elevation.

Table 1 – Elevations of the field center h_{fc} depending on the radiant elevation h_{rad} for the Perseids

Radiant elevation (h_{rad})	Field center elevation (h_{fc})
0°	90°
20°	80°
40°	70°
60°	60°
90°	45°

Table 2 – Recommended camera fields for observers at 45° northern latitude during the Perseid maximum. The azimuth A is counted as North = 0°, East = 90°, etc.

True Local Time	RadiantElevation (h_{rad})	Field Center	
		h_{fc}	A_{fc}
21ʰ	21°	80°	210°
22ʰ	26°	80°	210°
23ʰ	32°	70°	220°
00ʰ	39°	70°	220°
01ʰ	47°	60°	230°
02ʰ	55°	60°	230°
03ʰ	63°	60°	230°
04ʰ	70°	60°	230°

It cannot be predicted in advance which exposure time will be most suitable. If the activity exceeds the ability of visual counting, perhaps a 10 minute exposure is appropriate. For further increases in activity, 2 minutes may be long enough.

For each of the photographs, the following data are required in order that a scientific analysis can be made:

- date;
- the exact beginning and end of the exposure (±1 s if possible; use UT);
- the approximate field center in α, δ;
- site location and its geographic coordinates;
- focal length and speed of the lens;
- film type (sensitivity, format); and
- observer.

If you are lucky to record very high rates on photographic images, please send *copies* (on paper or film) of the negatives to the Acting Director of the Photographic Commission for further analyses (address see inside back cover). Please, do not only send "the best of your images," but also those obtained just before and/or after the highest rate.

2. Use of a video camera

If you have access to a video camera, you are encouraged to use it for meteor work as well. Although normal color camcorders are limited to about magnitude +2, the precise timing and frame-by-frame analyses possible with video equipment compensates for sensitivity limitations. Better sensitivities can be obtained with special high sensitivity monochrome video cameras, or with image intensified video cameras [1, 2].

Use the largest aperture possible with your video camera lens. If it is a zoom lens, you will want to select a fairly wide angle. Once you have selected a zoom setting, do not change it during the course of the observations. Set the focus to *manual* at infinity, as some types of automatic focus mechanisms will not operate properly when aimed at an almost black sky. For our purposes, you will not want to use the electronic shutter available on CCD video cameras since the sensitivity will be further impaired.

Turn the time display to *on* and set it to the finest time increment possible. Synchronize your clock time to a standard time signal. If no video time signal is possible with your camera, briefly blank the picture (by covering the lens) at several recorded times. Recording a short wave radio time signal on the audio track of the video recording offers another timing possibility. Use high quality video tape, and in most cases it is preferable to use the highest recording tape speed possible (e.g., SP in VHS, Beta I, or Beta II).

Select an observing direction in the same way suggested for photographic work, but adjust it as necessary to make sure that a minimum of three stars are visible in your field of view.

It will assist with photometric corrections if, at the beginning or ending of your observing period, you record several minutes of stars in the sky with the same camera settings but with the camera skewed at angular rates roughly corresponding to that of the expected shower. Note the identifications of the stars used in the test.

Immediately after the observations, make a copy of the video tape. It is acceptable (perhaps even preferable) to make this copy on a slow tape speed (e.g. SLP in VHS or Beta II), since frame-by-frame advance is better on most machines with slow tape speeds. In making the copy of your tape use the *video in* and *video out* connectors, rather than the RF modulated signal. Be sure to use shielded cables intended for video work in making the copy.

Carefully review the tape at least once (preferably twice) to make a listing of all meteor occurrences. This will make it easy for others to complete the analysis of your observations. For each meteor, note the following:

1. time (UT) to the nearest second;
2. position of meteor on the screen;
3. apparent direction of motion;
4. apparent angular speed (approximate); and
5. approximate apparent luminosity, in magnitudes.

Send this information and a copy of the tape to the *Visual Commission Director* as soon as possible.

References:

[1] R. Hawkes, "Constructing a Video-Based Meteor Observatory", *WGN* 18:4, August 1990, pp. 145–151.

[2] R. Hawkes, "Video-Based Meteor Observation Procedures", *WGN* 18:4, August 1990, pp. 152–158.

The 1994 Perseids: Radio Observations

Peter Brown and Bart Hock

1. Introduction

As described elsewhere in this issue, the possibility that the Perseids will produce a strong return in 1994 is prompting a comprehensive observing campaign by the *IMO*. One important aspect of this will be radio observations. Radio forward-scatter observations by amateur ham radio operators and others have been valuable contributors in the past few years to determining the time and peak strengths of the new Perseid peak [1]. Though the geometry involved can make interpretation more difficult, some basic measurements with a forward-scatter set up can provide useful data for the *IMO* analyzers trying to integrate information from the many observational methods to develop an overall picture of stream activity. Though no Radio Commission Director is presently appointed within the *IMO*, this should not deter those who wish to pursue this valuable means of meteor observation.

2. Overview

The process of observing meteor trails with radio is essentially a specular one. This is analogous to the case of reflection from a mirror in simple geometrical optics—the angle of incidence is equal to the angle of reflection. In the application of this general principle to radio, however, the visible light is replaced by a radio wave with a wavelength of order several meters and the mirror is the dense column of electrons produced when meteoric and atmospheric neutral atoms experience mutual collisions. The electron volume density is many orders of magnitude higher in the meteor trail than in the surrounding ionosphere and so supports reflection of much higher radio frequency (RF) waves (the atmosphere is a "natural" radio reflector for RFs below about 3 MHz).

The physical interaction of the radio waves with the meteor trail can be one of two types. If there are enough electrons to scatter in such a way that mutual interactions between nearby electrons is important, the radio wave cannot penetrate the full column of electrons and the column acts as though it were a long metallic conductor. Below this limit, the electrons act as individual scatters and are not affected by surrounding electrons to a great degree. These two broad categories of meteor trails are called overdense and underdense, respectively. They are delineated by the number of electrons produced per unit length of trail; the electron line-density. Overdense trails have line-densities in excess of roughly 10^{14} electrons/m.

In amateur forward-scatter observations, the transmitter is located many hundreds or thousands of km's from the receiver. The transmitter is generally an FM radio station, an aircraft beacon or a TV signal. The receiver is the "business" end of this arrangement where the amateur meteor observer detects radio waves scattered from the distant meteor trails. If the electrons in a meteor trail reflect effectively radio waves for only a short period of time, the trail is well approximated as a long, straight column of electrons. In this case (which is usually applicable to underdense trails), the geometry between the transmitter and receiver has to be such that the radio wave can reflect off the straight trail and reach the receiver. Such a geometry is only satisfied for a few of the many small meteor trails and hence some fraction of the total number of meteors will be detected. This geometry changes with the altitude of the radiant relative to the direction connecting the receiver-transmitter. The number of meteors you will detect further depends on the mean length of the meteor trails involved (which relates to the population or mass index), as longer trails offer greater probabilities of scattering from any one location. On top of these effects, the wavelength you use, the height of the maximum ablation for the meteors, the power and gain of the transmitter, and the gain of the receiver will all affect the detection efficiency of underdense trails.

To make meaningful quantitative interpretations of the flux of underdense meteors from forward scatter observations, all these effects (and more!) must be taken into account. In practical applications, this is further complicated as typical FM radio frequencies have overlap from many stations so that the amateur operating the receiver may really be detecting signals from many transmitters all of which are indistinguishable as far as the total echo rate is concerned. To make matters even worse, the small meteors that produce underdense trails are much more prolific in the sporadic background than in showers; even the Perseids at outburst produce a fraction of the total number of underdense trails.

To avoid all these pitfalls (and since no software has been developed in the *IMO* for analysis of radio observations once they are made), there are two useful modes of observation and some projects which maximize the scientific output of your radio observations which can be immediately interpreted.

3. Observational procedure

For many radio systems, the beginning of the overdense trail regime is near visual magnitude +5. As such, most overdense trails recorded by radio equipment should overlap quite well with visual observations during the Perseids. Furthermore, many overdense trails last long enough to distort in the upper atmosphere due to wind shear. In such cases, the trail loses much of its aspect sensitivity and multiple scattering centers may develop along the trail. Particularly for overdense trails corresponding to brighter meteors, some radio reflection should be registered by your receiver. Since aspect sensitivity is lost in these cases, the fact that multiple radio transmitters are present makes no difference. By counting the number of overdense trails as a function of time, you should be able to gauge the increase in Perseid activity quite accurately. Sporadic meteor rates will be completely overwhelmed at overdense echo durations by the increased flux of Perseids. The overdense radio echo is typified by a quick rise to maximum amplitude and then a near steady signal for a short time before the amplitude decays exponentially. One strong disadvantage in this case is when activity becomes very high, many echoes run together so that near continuous reception of the FM signal occurs. It is valuable to note both the number of overdense-type echoes you record as a function of time and also the time intervals where reflection is almost continuous due to the large flux of Perseids.

Another approach to radio observations of the Perseids is to maintain a consistent setup for several nights on either side of the maximum and record the number of echoes received. While ambiguities exist in this technique, it does give a rough relative indication of the increase in meteor rates near the time of maximum. Included in the word "consistent" is the direction of the antenna, the receiving antenna distance above the ground, the frequency used and the same observing times each day or night.

Once the total number of echoes has been counted for either or both of these modes of observation, the data should be passed on to the *IMO* Perseid Data Center to use for evaluating the shower's performance during any outburst. The impetus for the brief and highly simplified procedure described here and the basic physics involved are extensively described in [2]—the serious amateur radio observer should become familiar with the material covered in that text.

A potential source of RF for this year's Perseid shower is the VHF radar operated by the Johnson Space Center for meteor and debris work. This backscatter radar operates at 49.92 MHz with a peak output of 33 kW. It has a pulse repetition frequency of between 100 Hz and 1000 Hz (typically at 500 Hz) with a pulse duration of 50 microseconds. It is to be operated from $\varphi = 29\overset{\circ}{.}58$ N, $\lambda = 95\overset{\circ}{.}06$ W (the Johnson Space Center) during the 1994 Perseids. The radar should become operational several days before shower peak and remain operational several days past peak. The radar emits a right handed, circularly polarized pulse, in the vertical direction. For the Perseid shower, the beam is intentionally fat to give essentially an "all-sky" view. While this reduces the effective radiated power, it increases the total meteor count.

Using this system in 1993, several days worth of data were taken during the Perseid shower. These data are not yet fully analyzed. One item of note from the 1993 data is the apparent increase in sky noise within 3 to 5 seconds of some large Perseid returns. This apparent precursor reflection could indicate a dust cloud surrounding some larger meteors or could be a statistical fluke.

If some meteoroids have a halo of smaller objects traveling with them (or material fragmented in the near-Earth environment), the arrival of these objects at the upper atmosphere could trigger a slight enhancement of the reflectivity of the atmosphere leading to the precursor signal. Radio observers are encouraged to look for this noise enhancement. If not regularly observed, the probability of simple coincidence between meteor arrival and noise enhancement is high. If, on the other hand, the precursor occurs with statistical significance we will have discovered new information about the makeup of the Perseid Meteor Stream. All radio reports will be critical in making this determination.

References

[1] P. Brown, M. Gyssens, J. Rendtel, "New Outburst Announces Return of P/Swift-Tuttle", *WGN* 20:5, October 1992, pp. 192–197.

[2] D.W.R. McKinley, "Meteor Science and Engineering", McGraw-Hill, New York, 1961.

Telescopic Notes for the 1994 Perseids

Malcolm J. Currie

1. Introduction

Judging by the 1993 Perseid flux of faint meteors, even if there is a very strong visual outburst as some speculate, it is unlikely to cause much difference to the telescopic observer. Even an unlikely five-fold increase on the 1993 performance only amounts to rates around 10 per hour. Combined with other showers and sporadic meteors this does not exceed the rate where plotting becomes unfeasible, some 30 meteors per hour. However, given recent surprises, you the observer should be prepared in case this turns out to be conservative. The suggestions below should give you a chance to witness both the spectacle and to obtain important data.

Even with normal Perseid rates there is still much of interest for the telescopic observer. For example, we can see if the possible sub-radiant observed last year [1] has persisted and/or any other sub-radiants are present. There are also several minor showers in the vicinity whose properties are poorly known.

2. What to do in the event of a Perseid outburst

To know what to do in this circumstance depends on what we are trying to discover about the Perseids. Of particular interest is to compare the properties of the debris left by the 1862 passage of Comet P/Swift-Tuttle, and the older material that has experienced evolutionary effects since it was released. If we want to determine properties of the radiant, such as any displacement from the normal position, the presence of any sub-radiants, and size changes, this requires careful plotting. However, not all the meteors need to be recorded once the rate becomes high. If we seek the population index as a function of time, the approximate flux during strong activity, or even form a rate curve for comparison with visual observers then all you need record are magnitude estimates and a shower assignment for *all* the meteors. So if rates get too high to plot all meteors, you should select one of the two techniques described below until the rate subsides to a manageable level. Being greedy we want both. Therefore, to prevent all observers doing the same thing in the event of an outburst, I ask observers with narrow apparent fields (less than 55°) to plot, and those with wide fields to count. Specify on the report sheet if you depart from the normal method.

Plotting

Since any outburst may only be brief—about an hour during the 1991 and 1992 returns—it will be important to change field centers frequently and rapidly. An effective observing time of 5–10 minutes per field looks sensible. If we are very lucky and high rates last for many hours this will increase the dead time, but it will give you a chance to watch some of the naked-eye activity, which you will not want to miss. Plot the first meteor you see clearly each time you move to the eyepiece; this is to reduce a bias towards plotting only the bright meteors. To increase the number of plotted meteors it is not necessary to record the appearance time, type, and magnitude of an individual plotted meteor during an outburst, but do estimate its speed. If you can record the magnitude, record it on the chart next to the meteor. Note on the report sheet that you are plotting only some of the observed meteors. It will take concentration not to be distracted by other meteors while you are memorizing another, so be sure that you know what you saw before switching on the flashlight and recording the meteor. Practice locating the telescopic fields. You do not want to spend ten minutes during high rates fumbling around. Get to know the telescopic fields, so that you can plot meteors more quickly against a familiar background.

Since there is a good chance of many bright meteors crossing your field you may well see the decay of persistent trains. You will have to use discretion whether or not to record their decay.

Counting

For every meteor record just the brightness (to the nearest half of a magnitude) and the shower assignment (if it is not a Perseid). Use a tape recorder to minimize the dead time. Since we want to watch the varying meteor rate, use a stop watch to record the actual effective observing time or the dead time if you cannot use a tape recorder. The recording or your notes should be time-tagged frequently—say at ten-minute intervals—so that fluctuations in the rate curve are not smeared by binning into long intervals. Ensure that your timepiece is accurate to better than 30 seconds. If a high rate starts, stick with your current field rather than alternating. Besides saving dead time it does not introduce other variables which might affect the observed rate. Prior to observing note a selection of comparison stars that have a wide spread in brightness for quick magnitude estimates. The charts have a key and the plotted star diameters are linearly related to the magnitude.

3. General remarks

There are six field centers in an arc mostly north of the Perseid radiant, about 15° distant (charts 3, 13, 18, 19, 35, and 39). Try to use them all. When you are plotting meteors, do not start with an adjacent pair of fields, but pick a pair with another intervening, for example 3 and 18, 13 and 19. This is to obtain a more accurate fix of the radiant if the fickle clouds roll in. When the Perseid radiant has an elevation below 25°, observations using chart 9 or 32 should help to resolve the ambiguity of three minor shower radiants [1]. Given the Perseids' paucity of faint meteors a small-aperture instrument is preferred, say at most 50 mm.

Remember that you should continue to make normal telescopic watches of duration 20–40 minutes per field unless the rate exceeds about 30 meteors per hour. Only use the special methods described earlier for higher rates. Given the relatively low number of telescopic Perseids to sporadics I do not expect you to face these pleasant problems. Nevertheless you should be ready ... just in case.

A set of charts, report sheets, and instructions and examples how to complete them are available from me. State the field of view and typical stellar limiting magnitude of the binocular or telescope you intend to use so that I can select the appropriate chart set.

References

[1] M.J. Currie, "Telescopic Results near the 1993 Perseids' Maximum", *WGN* 22:2, April 1994, pp. 37–46.

From the Meteor Library

compiled by Marc Gyssens and Paul Roggemans

- *Zidian Wu and Iwan P. Williams, "The Perseid Meteor Shower at the Current Time," Monthly Notices of the Royal Astronomical Society 264, 1993, pp. 980–990.*

The Perseid Meteor Shower is a well-known feature of the mid-August sky, and the event is generally assumed to be associated with Comet P/Swift-Tuttle. Over the last few years, there has been increasing activity observed within the Perseid display, and this was interpreted by some as an indication that the parent comet was again approaching the Earth. This conjecture was proved correct with the recovery of Comet P/Swift-Tuttle in October 1992. The formation of a stream of meteoroids by ejection from Comet P/Swift-Tuttle at its last apparition in 1862 and its subsequent evolution under the effects of the gravitational perturbations of the planets Earth, Jupiter, Saturn, and Uranus are investigated. It is found that such meteoroids could be mainly responsible for the new activity observed a few hours prior to the traditional activity. The model also suggests that the new activity may continue to increase in prominence at least until 1994, and will continue to be observable into the next century.

- *Iwan P. Williams and Zidian Wu, "The Current Perseid Meteor Shower," Monthly Notices of the Royal Astronomical Society, 1994, to appear.*

The Perseid Meteor Shower is one of the regular showers occurring in August each year. Over the last few years, a new peak in the activity curve of the Perseids has appeared, about half a day before the established peak. It was generally agreed that this new peak represented meteoroids ejected at a recent perihelion passage of the parent comet, and the rediscovery of Comet P/Swift-Tuttle re-enforced this view. A model by Wu and Williams (1993, *see above, ed.*) suggested that this new peak should reach its maximum activity in 1994 rather than 1993 and that a strong display, but not a storm, should be expected. We present here an improved model which again suggests that the 1994 Perseids should be marginally stronger than in 1993, with the peak occurring at a solar longitude of about 139°.55. It is predicted that, after 1994, the new peak will start to reduce.

Ongoing Meteor Work

Meteor Observations at Přerov during 1934–1943

Miloš Weber

The results of naked-eye observations from Přerov ($\lambda = -17°27'49''$, $\varphi = +49°27'15''$, $h = 212$ m) are presented. In total, 10 observers observed 8414 meteors in 367 nights during 629.6 hours. The sum of the observing time of all observers is 1194.7 hours, and the sum of the meteor counts is 9445. In this paper, the results of the statistics of sporadic meteors, i.e., the annual variation of hourly rate and average population index are presented.

1. Introduction

The results presented in this paper are based on naked-eye observations from Přerov ($\lambda = -17°27'49''$, $\varphi = +49°27'15''$, $h = 212$ m). In total, 10 observers observed 8414 meteors in 367 nights during 629.6 hours. The sum of the observing time of all observers is 1194.7 hours, and the sum of the meteor counts is 9445. This series of observations spans the period 1934–1943 and has both positive and negative points.

The positive points of this series of observations are the following:

- The observations were carried out by 7 permanent observers (the observations of 3 seasonal observers having been discarded);
- The observations were carried out in a provincial town under a low level of artificial illumination in the period 1934–38, and under total darkness during the war period 1939–43.

The negative points of this series of observations are the following:

- There is a lack of observations at positive elevations of the Earth's apex;
- The observing site has a low elevation above sea-level (and accordingly poor meteorological conditions)

During the reduction of these observational data for the the sporadic meteors, all observations performed under poor conditions were discarded, i.e.,

- observations with limiting stellar magnitude inferior to 5.8;
- observations with cloudiness greater than 20%;
- observations carried out during the first year of the series (1934) (the observing data from the subsequent years 1935 and 1936 were weighed with a coefficient 0.5);
- observations performed by the 3 seasonal observers;
- observations performed during the maxima of major shower activity, i.e. (shower, interval of solar longitude, eq. 1950.0), Lyrids ($30\overset{\circ}{.}5$–$31\overset{\circ}{.}5$), Perseids (137°–141°), Orionids (207°–208°), Leonids (234°–235°), and Geminids (259°–263°); and
- observations lasting more than 180 minutes were divided into intervals of at least 60 minutes of net observing time.

¿From all 367 nights, 310 nights with 348 observing intervals were selected. For the reduction of sporadic meteor observations, 314 out of these remained [1,2,3].

2. Observers

Below is the list of observers that took part in the observations. In order, name, abbreviation, number of nights, number of hours, and number of meteors are given:

> Marie Hlaváčová (H, 11, 19.6, 144), Miloš Venclik (V, 179, 344.9, 2425), Jan Němec (N, 82, 150.4, 1442), Miloš Weber (W, 209, 374.4, 2980), Bořivoj Dobíšek (B, 72, 126, 964), Mojmír Dobíšek (M, 78, 140.1, 1397), and Slavoj Dobíšek (S, 17, 26.5, 440).

The seasonal observers whose observations were not used in the present analysis were Mirko Hudecek, Vladimír Kryštovský, and František Kupka.

3. Observing method

The observing team was composed of from one up to four observers, watching one to four directions between the zenith and 10° elevation. One observer simultaneously recorded the data while another plotted the meteors seen. During periods of high hourly rates, the recorder ceased observing. Cloudiness, if present, was recorded in 10-minute intervals, the limiting stellar magnitude every hour. No observations were done during moonlight or twilight.

Table 1 – Distribution of observing intervals.

Year	1935	1936	1937	1938	1939	1940	1941	1942	1943	Total
Intervals with:	39	36	61	64	40	56	25	15	12	348
1 obs.	9	15	14	29	8	17	16	7	6	121
2 obs.	28	13	21	14	17	37	7	6	5	148
3 obs.	2	8	18	17	13	1	2	2	1	64
4 obs.			8	4	2	1				15
$T_{\rm eff}$ ($^{\rm m}$)	5903	6485	13028	10554	7984	7915	2678	1970	1323	57840

The mean hourly rates were computed according to the following formula:

$$\mathrm{HR}_o = \frac{60 \times N_o \times C_{\rm Lm} \times C_F \times C_P}{\sum t'}, \tag{1}$$

where the factors C are the weighted mean values of all observers in the team according to the following formula:

$$C_{\rm av} = \frac{\sum C_i \times w_i}{\sum w_i}. \tag{2}$$

The meaning of individual values is as follows:

- HR_o is the observed mean hourly rate of one observer;
- N_o is the number of sporadic meteor sightings;
- $\sum t'$ is the sum of net observing time of all observers in the team (from the total time, the time for recording, plotting, manipulating photographic cameras, and pauses was subtracted);
- $C_{\rm Lm}$ converts the hourly rate observed with the actual limiting stellar magnitude into the standard hourly rate with Lm = 6.0;[1]
- C_F is the factor converting the hourly rates with the actual cloudiness into the standard hourly rates with 0% cloudiness;
- C_P is the personal factor converting the hourly rate of each observer into the average hourly rate of the team, computed for each observer and for each year from the observations of the complete team;
- $C_{\rm av}$ is the mean coefficient of all observers in the team, and w is the weight of the observed data. For the years 1935 and 1936, $w = 0.5\,t'$; for the years 1937 to 1943, $w = t'$.

The table of the basic data from all 314 observing intervals is too extensive for publication. The important results are summarized in Table 2 and their graphical representation is in Figures 1 (a) and (b).

[1] *Notice that the* IMO *reduces to* Lm = 6.5. (Ed.)

Table 2 – Average hourly rates of sporadic meteors in bins of 10° of solar longitude.

$\lambda_\odot$ (1)	H_A (2)	o (3)	Y_o (4)	$\sum N_o$ (5)	$\sum w$ (6)	HR_o (7)	SD (8)	$^n\mathrm{HR}_o$ (9)	SD (10)
2.2	−46.0	7	3	40	381	4.87	0.77	0.59	0.09
16.4	−43.1	11	2	158	1822	5.30	0.42	0.64	0.05
22.0	−39.6	10	3	144	1325	6.42	0.54	0.77	0.06
35.9	−41.4	7	5	61	665.5	5.06	0.65	0.61	0.08
44.7	−20.6	9	4	62	739.5	5.15	0.65	0.62	0.08
53.9	−10.4	3	2	25	178	6.88	1.38	0.83	0.17
67.6	−18.5	6	3	76	793	6.01	0.69	0.72	0.08
75.5	−14.3	13	4	211	1823.5	6.85	0.47	0.83	0.06
86.5	− 3.3	4	3	81	724	6.55	0.73	0.79	0.09
96.1	+ 0.3	12	4	257	1976.5	7.30	0.46	0.88	0.05
105.7	− 0.8	8	3	200	1619	7.84	0.55	0.94	0.07
114.4	+ 0.7	12	4	344	2123	9.01	0.49	1.09	0.06
125.0	+ 8.1	26	7	880	4311.5	11.67	0.39	1.41	0.05
133.6	+11.7	29	8	961	5382	9.83	0.32	1.18	0.04
146.8	+ 5.6	16	6	552	2944	12.28	0.52	1.48	0.06
156.8	− 0.2	20	7	448	2457	8.97	0.42	1.08	0.05
164.1	+ 6.5	18	6	507	3407.5	8.24	0.37	0.99	0.04
175.3	− 3.3	17	4	429	2100.5	8.75	0.42	1.05	0.05
183.7	− 2.4	8	3	124	1013	6.74	0.61	0.81	0.07
192.8	− 4.9	6	3	88	820	6.88	0.73	0.83	0.09
205.6	−13.8	3	1	23	287	5.06	1.06	0.61	0.13
216.7	− 8.4	8	2	278	2023.5	8.51	0.51	1.03	0.06
227.5	+40.6	1	1	55	209	15.30	2.06	1.84	0.25
237.2	−19.2	4	3	37	337	6.52	1.07	0.79	0.13
245.0	−11.6	10	5	132	1116.5	7.17	0.61	0.86	0.07
253.9	−23.2	4	3	53	430.5	7.36	1.01	0.87	0.12
265.9	−30.4	5	4	46	462.5	5.55	0.82	0.67	0.10
272.8	−31.6	6	3	87	1029	5.91	0.63	0.71	0.08
288.7	−33.5	1	1	9	116	5.80	1.93	0.70	0.23
295.2	−42.4	3	2	18	280	4.33	1.07	0.52	0.13
306.7	−20.3	3	2	19	231	5.53	1.27	0.67	0.15
318.3	−45.6	2	2	25	319	5.92	1.18	0.71	0.14
323.6	−39.3	5	3	48	384	7.46	1.08	0.90	0.13
337.4	−40.8	6	2	50	613	4.89	0.69	0.59	0.08
345.7	−43.2	4	2	33	284	7.29	1.27	0.88	0.15
353.8	−40.6	7	4	79	921	4.81	0.54	0.58	0.07
Sum		314		6640	45648.5				
Mean	−7.3					8.29			

The meaning of the values in the individual columns of Table 2 is as follows:

1. the weighted average of the solar longitude, $\lambda_\odot$, in degrees in each of the 10° bins;
2. the weighted average of the apex elevation, H_A, in degrees;
3. the number of observing intervals included, o;
4. the number of different years in which the included observations were performed, Y_o;
5. the sum of the number of meteor sightings, $\sum N_o$, i.e., each commonly observed meteor is included as many times as it was observed;
6. the total weight, $\sum w$, of all observations in the solar longitude range under consideration;
7. the average of observed hourly rates, reduced to standard observing conditions, corresponding to the mean solar longitude (Column 1) and to the mean apex elevation (Column 2);
8. SD is the natural uncertainty of HR_o according to the approximation $SD = \mathrm{HR}_o/\sqrt{n}$ (3);

Table 2 – Continued.

$\lambda_\odot$ (1)	HR_c (11)	RR (12)	^nRR (13)	*SD* (14)	HR'_c (15)	RR′ (16)	$^nRR'$ (17)	*SD* (18)
2.2	5.13	0.95	1.04	0.16	7.54	0.65	0.70	0.11
16.4	5.31	1.00	1.09	0.09	7.43	0.71	0.76	0.06
22.0	5.51	1.16	1.27	0.11	7.49	0.86	0.92	0.08
35.9	5.41	0.94	1.03	0.13	7.00	0.73	0.78	0.10
44.7	7.09	0.73	0.80	0.10	7.94	0.64	0.69	0.09
53.9	8.12	0.83	0.91	0.18	8.17	0.83	0.89	0.18
67.6	7.21	0.84	0.92	0.11	7.17	0.84	0.90	0.10
75.5	7.57	0.90	0.98	0.07	7.17	0.96	1.03	0.07
86.5	8.75	0.76	0.83	0.09	7.60	0.87	0.93	0.10
96.1	9.16	0.80	0.88	0.05	7.66	0.92	0.99	0.06
105.7	9.02	0.87	0.95	0.07	7.37	1.07	1.15	0.08
114.4	9.18	0.98	1.07	0.06	7.37	1.22	1.31	0.07
125.0	10.02	1.16	1.27	0.04	8.01	1.47	1.58	0.05
133.6	10.45	0.94	1.03	0.03	8.23	1.19	1.28	0.04
146.8	9.44	1.29	1.41	0.06	7.71	1.57	1.68	0.07
156.8	9.09	0.99	1.08	0.05	7.17	1.25	1.34	0.06
164.1	9.89	0.83	0.91	0.04	7.94	1.04	1.12	0.05
175.3	8.74	1.00	1.09	0.05	7.06	1.24	1.33	0.06
183.7	8.93	0.76	0.83	0.07	7.37	0.91	0.98	0.09
192.8	8.59	0.80	0.88	0.09	7.31	0.94	1.01	0.11
205.6	7.62	0.66	0.72	0.15	6.63	0.76	0.82	0.17
216.7	8.24	1.03	1.13	0.07	7.80	1.09	1.17	0.07
227.5	13.70	1.12	1.23	0.17	11.93	1.28	1.37	0.18
237.2	7.13	0.91	0.99	0.16	7.43	0.88	0.94	0.15
245.0	7.93	0.90	0.99	0.08	8.43	0.85	0.91	0.08
253.9	6.81	1.08	1.18	0.16	7.63	0.96	1.03	0.14
265.9	6.08	0.91	1.00	0.15	7.46	0.74	0.79	0.12
272.8	6.05	0.97	1.06	0.11	7.66	0.77	0.83	0.09
288.7	5.90	0.98	1.07	0.36	7.69	0.75	0.80	0.27
295.2	5.24	0.83	0.91	0.22	6.63	0.66	0.71	0.17
306.7	7.02	0.79	0.86	0.20	9.75	0.57	0.61	0.14
318.3	5.10	1.16	1.27	0.25	7.28	0.81	0.87	0.17
323.6	5.52	1.36	1.49	0.22	8.12	0.92	0.99	0.14
337.4	5.43	0.90	0.98	0.14	8.17	0.60	0.64	0.09
345.7	5.30	1.37	1.50	0.26	7.92	0.92	0.99	0.17
353.8	5.38	0.90	0.98	0.11	8.26	0.58	0.62	0.07

9. the normalized hourly rate, $^n\mathrm{HR}_o$, defined by $^n\mathrm{HR}_o = \mathrm{HR}_o/8.3$ (4), where 8.3 meteors per hours is the weighted average of all 314 observed HR_o; and
10. *SD* is the natural uncertainty of $^n\mathrm{HR}_o$.

The meaning of the quantities given in Columns 11–18 is explained in the following sections.

By comparison with the observation series at Skalnaté Pleso [4], we obtain a weighted mean observed HR of 8.3 sporadic meteors/hour at Přerov versus 17.2 at Skalnaté Pleso. The unweighted mean observed HR equals 7.2 sporadic meteors/hour at Přerov versus 13.1 at Skalnaté Pleso. The difference must be attributed in part to meteorological conditions: Přerov is only 212 m above sea-level, while Skalnaté Pleso is 1783 m above sea-level. The difference can be explained further by the lack of observations with $H_A > 0°$ in the Přerov series.

4. Reduction to Hoffmeister's model of radiant distribution

For the purpose of establishing the dependency of the hourly rate upon the position of the apex, the 314 observing intervals have been distributed into eleven groups according to the apex elevation. In each group, the weighted mean elevation of the apex, H_A, and the weighted mean observed hourly rate, HR_o, have been calculated. Using the method described in [5], the approximate values of Hoffmeister's parameters c_o and k_o were found, after which the final values of c and k were computed by the method of least squares.

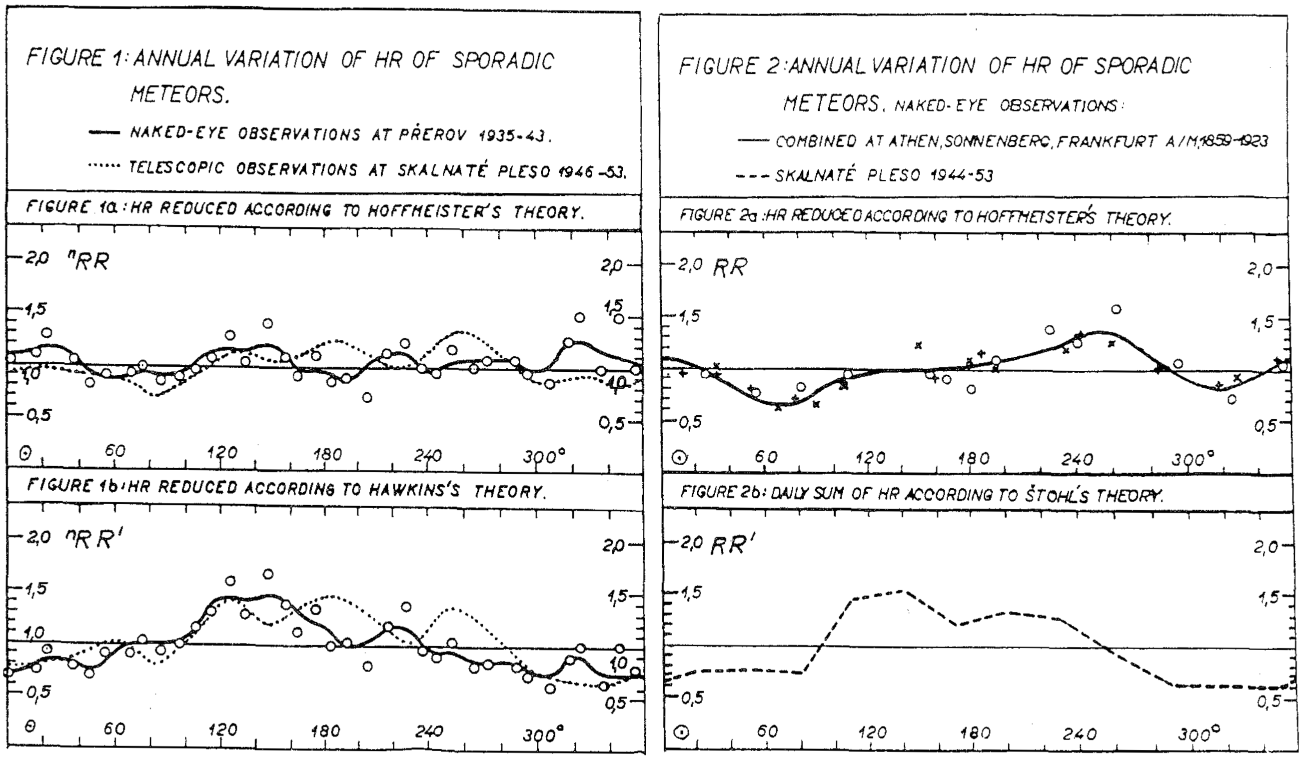

Figure 1 – Figure 2 – Annual variation of sporadic meteors.

The value of c may be considered as a measure for the apparent concentration of radiants to the apex, and may be used for eliminating the effect of this concentration from the observations. The second parameter of Hoffmeister, k, is the mean hourly rate corresponding to $H_A = 0°$. The final values are $c = 2.82$ and $k = 9.10$, and the resulting formula for computing the theoretical hourly rate, HR_c, is

$$\mathrm{HR}_c = 9.10(1.0616 + 0.7212 \cos z_A + 0.0616 \cos 2z_A), \tag{5}$$

where $z_A = 90° - H_A$ is the zenith distance of the apex.

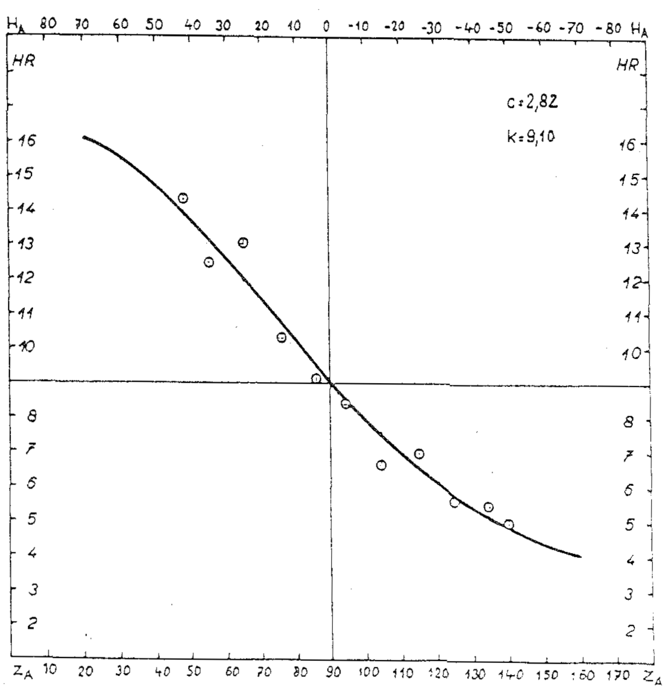

Figure 3 – Daily variation of hourly rates of sporadic meteors from Přerov (1935–1943), according to Hoffmeister's theory.

A graphical representation of the results is in Figure 3. The open circles represent the mean observed hourly rates, HR_o, plotted against the mean apex elevation H_A or zenith distance z_A. The bold line is a graphical representation of formula (5), i.e., the values of the computed HR_c as a function of H_A or z_A.

In order to study the irregularities in the variation of hourly rates, we may eliminate the effect of the apex elevation by introducing a reduced hourly rate, RR, defined by

$$\mathrm{RR} = \frac{\mathrm{HR}_o}{\mathrm{HR}_c}. \tag{6}$$

This method of eliminating he diurnal variation of the hourly rates was also applied by M. Kresáková and L. Kresák in 1955 and 1966 [2,3].

Comparing the values of c and k derived from the observations at Přerov with other observations, we obtain the following:

Přerov, 1934–1943, naked-eye,	$c = 2.82$,	$k = 9.10$;
Hoffmeister, 1909–1921, naked-eye, Sonneberg [6],	$c = 2.39$,	$k = 8.78$;
Schmidt, 1859 et seq., naked-eye, Athens [6],	$c = 2.88$,	$k = 10.55$;
Kresáková, 1946–1953, telescopic, Skalnaté Pleso [2],	$c = 3.9$,	$k = 3.19$.

The explanation of the differences may be the following:

- the actual variations in the density of meteoroids around the Earth's orbit;
- the lack of observations in the Přerov series;
- the differences in the elimination of minor meteor showers from the sporadic background; and
- the variation of the activity of the unidentified minor showers.

The resulting values according to Hoffmeister's model are incorporated in Table 2. Column 11 shows the weighted mean values of HR_c in ranges of 10° of solar longitude, and Column 12 shows the weighted mean reduced hourly rates, RR.

¿From the graphical representation of the values RR plotted against solar longitude, it is evident that the curve of annual variation of RR is situated mostly under the value RR = 1 corresponding to $H_A = 0°$. The reason is that the weighted mean apex elevation from the series of observations is $H_A = -7.°2$ (see Column 2 in Table 2). The value of HR_c at this apex elevation $H_A = -7.°2$ is 8.32 from formula (5). The values RR were normalized to the values ^{n}RR using the coefficient 1.094 = 9.10/8.32 according to the formula

$$^{n}\mathrm{RR} = 1.094\mathrm{RR}. \qquad (7)$$

The weighted mean values of ^{n}RR are listed in Column 13 of Table 2, and their natural uncertainties, SD, in Column 14. A graphical representation of the values ^{n}RR is in Figure 1 (a). The bold line shows ^{n}RR from Přerov naked-eye observations and the dashed line shows ^{n}RR from Skalnaté Pleso telescopic observations [2]. In Figure 2 (a), the annual variations of the hourly rates of sporadic meteors are plotted, compiled from the observations of Schmidt (circles, Athens, 1859 et seq.), Hoffmeister (plusses, Sonneberg, 1909–1921), and Heybrock (crosses, Frankfurt a/M, 1919–1923), as published by Hoffmeister [6]. The reduction of the hourly rates is carried out according to Hoffmeister's model to the apex elevation $H_A = 0°$. Figures 1 (a) and 2 (a) make it possible to compare the Přerov results with the results of the combined naked-eye observation series at Athens, Sonneberg, and Frankfurt, and with the telescopic observations at Skalnaté Pleso, reduced according to Hoffmeister's one-source model. All the graphical representations indicate the observed or calculated values by circles, plusses, or crosses; the lines in Figures 1 (a), 1 (b), and 2 (a) are smoothed using the formula

$$\mathrm{HR}^s = \frac{\mathrm{HR}_{i-1} + 2\mathrm{HR}_i + \mathrm{HR}_{i+1}}{4}. \qquad (8)$$

5. Reduction to Hawkins's model of radiant distribution

In this section, the relative hourly rates, RR′, are computed according to the radiant distribution model which was described by Hawkins [7] in 1956. Hawkins published the tables of expected hourly rates computed by numerical integration in his model as a function of the geographical latitude. For the reduction of Přerov observations (latitude 49.°5 N), Hawkins's table for the latitude 50° N was applied. For each Přerov observation, the expected hourly rate HR'_c may be found by interpolation in Hawkins's table. In order to avoid double interpolation in Hawkins's table as an additional source of inaccuracy, Kresáková [3] has constructed an auxiliary diagram for determining HR'_c for each observation from solar longitude and apex elevation or from the date and hour of observation. The same method is used in this paper.

The interpolated values of HR'_c are the radio-echo rates defined as the numbers of meteors brighter than magnitude +5, penetrating an area of 1000 km^2 during one hour. The transformation of these values to the values of naked-eye observations in an unlimited field of view was performed by comparing the mean hourly rate $\mathrm{HR}'_c = 3.174$ from Hawkins's table for $H_A = 0°$ with the mean hourly rate of the Přerov observations, $\mathrm{HR}_c = 9.10$, at the same $H_A = 0°$. Hawkins's values, interpolated from Kresáková's auxiliary diagram, are multiplied by the coefficient $2.868 = 9.10/3.174$, and listed as HR'_c in Table 2, Column 15. The reduced rates

$$\mathrm{RR}' = \frac{\mathrm{HR}_o}{\mathrm{HR}'_c} \tag{9}$$

are listed in Table 2, Column 16. The weighted mean value of HR'_c corresponding to weighted mean apex altitude $H_A = -7\overset{\circ}{.}2$ is 2.959. The coefficient used for the normalization of RR' to ${}^n\mathrm{RR}'$ is $1.073 = 3.174/2.959$. Thus

$${}^n\mathrm{RR}' = 1.073\mathrm{RR}'. \tag{10}$$

These values are listed in Table 2, Column 17, and their natural uncertainties, SD, in Column 18. Provided that Hawkins's model of radiant distribution is valid, the reduced rates RR' and normalized rates ${}^n\mathrm{RR}'$ should be free from the effect of radiant distribution, and should reveal the irregularities in the density distribution of meteoroids around the Earth's orbit.

A graphical representation of the annual variation of reduced and normalized hourly rates, ${}^n\mathrm{RR}'$, is presented in Figure 1 (b). The bold line is derived from Přerov naked-eye observations, the dashed line represents the results of Skalnaté Pleso telescopic observations for comparison. It is obvious that the curve of the annual variation of sporadic meteor hourly rates reduced according to the model of Hawkins differs from the curve reduced according to the model of Hoffmeister. Figure 1 (b) compares Přerov results with the results of the telescopic observation series at Skalnaté Pleso, reduced by a fully identical method, according to Hawkins's three-source model. The annual variation curve in Figure 2 (b) shows the results of naked-eye observations at Skalnaté Pleso, based on Štohl's [4] modification of the three-source model. The graphical representation of the hourly rates differs from the other curves as it gives the relative values of daily sums of the hourly rates for all hours of the whole day and night of observation, i.e., the "daily rates." It is obvious that the curves of annual variations at Přerov and at Skalnaté Pleso, reduced according to the three-source models, show some resemblance.

6. Luminosity function of sporadic meteors

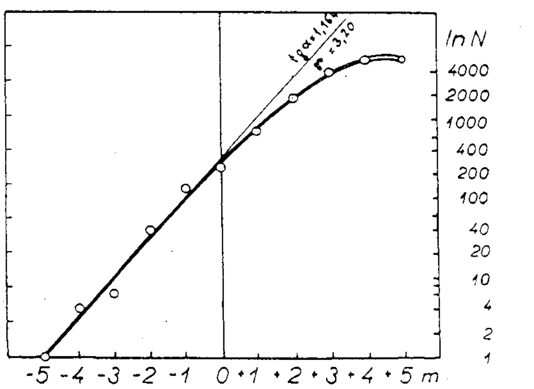

Figure 4 – Luminosity function of sporadic meteors at Přerov, 1935–1943.

The meteor magnitudes were estimated in whole numbers. The range of observed magnitudes, m, is from −5 to +5. The total number of estimates is 5684. The curve of observed values was approximated by a polynomial of the third order, and the following formula was obtained:

$$\ln N = 5.65822 + 1.02432m - 0.047832m^2 - 0.005465m^3. \tag{11}$$

The tangent in the point of inflection simulates a linear luminosity function with the slope, i.e., the population index, $r = 3.20$ and the mass index $s = 1 + 2.5\log r = 2.26$. The slope of the luminosity curve was derived according to [8]. The graphical representation of the luminosity function derived as the tangent to the approximate polynomial (bold line) is shown in Figure 4. The open circles are the observed data. M. Kresáková has found $r = 3.4$ in [9].

References

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Fireballs and Meteorites

Extremely Bright Daylight Fireball

North Sea, May 29, 1994, $9^h32^m \pm 1^m$ UT

communicated by Casper ter Kuile

An extremely bright daylight fireball with an estimated visual magnitude of −20 was seen over the North Sea by observers on the Dutch and English coasts and in Belgium on May 29 around 9^h32^m UT (which is very close to local time).

On the morning of May 29, 1994, around 9^h32^m UT several observers near the Dutch coast, which was mostly clear at that time, saw an extremely bright fireball, which was much brighter than the Full Moon. Magnitude -20 ± 3 seems to be the most reasonable estimate. Most observers described the fireball as an intense flashlight, dazzling, like a welding flame. The brightest part of the fireball lasted for about 2 seconds. A wide variety of colors was reported. Because of the daylight, most observers did not notice the first part of the fireball. For the same reason, no traditional persistent train was seen although many observers report a smoke or dust train lasting at least several minutes. It is not yet clear whether fragmentation occurred. No sounds were reported.

The data given here were compiled by members of the *Dutch Meteor Section*, based on Dutch observations and British observations communicated by Neil Bone of the *British Astronomical Association*. The fireball appeared about 100 to 150 km west of Egmond-aan-zee, a small Dutch town about 40 km south of Den Helder. Presumably, the meteor traveled from about NNE to SSW. The entrance angle is estimated at 45° to 60°. A very low velocity of about 10 km/s has been calculated. From these data, a (sea) impact cannot be excluded.

Because of the high entrance angle, it is very improbable that the fireball was caused by a satellite re-entry. Furthermore, no such event was expected. Rough orbit calculations suggest that the fireball moved on an asteroidal orbit.

Fireball

Poland, May 7, 1994, $20^{h}03^{m}41^{s} \pm 5^{s}$ UT

Pavel Spurný, Ondřejov Observatory

On the night of May 7, 1994, a very slow-moving fireball of approximately −8 maximum absolute magnitude was photographed by two Czech stations of the European Fireball Network.

A very slow-moving fireball of −8 maximum absolute magnitude was photographed by two Czech stations of the European Fireball Network on the night of May 7, 1994. The fireball traveled a 61.95-km luminous trajectory in 5.14 seconds and terminated its light at a height of 42.71 km. The following accurate results are based on all available records. Time of the fireball passage was taken from the very precise visual observation. In spite of a long distance of the fireball trajectory from both stations (more than 200 km from the first station and about 250 km from the second one) and the small angle of the corresponding meteor planes (10°), all values, as is shown below in the tables, were determined with good accuracy thanks to a new type of reduction of the photographs taken by our all-sky cameras equipped with fish-eye objectives. This new method of reduction enabled us to determine the position with a precision of 1′ for any object recorded in the wide range of zenith distances from 0° to 88° and in the whole range of azimuths from 0° to 360°.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	13.71 ± 0.02	12.32	8.6 ± 0.3
Height (km)	63.56 ± 0.04	51.00	42.71 ± 0.04
Latitude (° N)	51.4614 ± 0.0004	51.523	51.5637 ± 0.0004
Longitude (° E)	15.4953 ± 0.0002	15.984	16.3124 ± 0.0002
Abs. magnitude	− 5.5 ± 0.3	− 8.36 ± 0.13	− 5.8 ± 0.3
Photomet. mass (kg)	20.7	12.3	less than 0.01
Z R (°)	70.1 ± 0.3		70.6 ± 0.3

Fireball type: II
Ablation coefficient: (0.048 ± 0.005) s^2/km^2

Table 2 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	113.3 ± 0.3	101.4 ± 0.3	
δ (°)	+ 08.5 ± 0.3	− 06.3 ± 0.3	
λ (°)			129.53 ± 0.06
β (°)			− 06.85 ± 0.07
Initial velocity (km/s)	14.01 ± 0.02	8.93 ± 0.04	36.56 ± 0.05

Table 3 – Orbital data.

Orbit (2000.0)	
a	2.104 ± 0.018 AU
e	0.532 ± 0.004
q	0.9842 ± 0.0005 AU
Q	3.22 ± 0.04 AU
ω	338°.2 ± 0°.2
Ω	227°.1096 ± 0°.0001
i	6°.91 ± 0°.07

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