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This spectacular Northern Taurid fireball was photographed by an Ondřejov guiding camera with fish-eye objective (f = 30 mm, $f/3.5$) on November 18, 1993, at $18^h19^m00^s$ UT. More on this fireball can be found on p. 55 of this issue.

In this issue:

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

WGN, Vol. 22, No. 2, April 1994, pp. 27–80

Contents

Useful Information

The June Issue *(WGN 22:3)*

The *June issue* is anticipated to be a thick issue and will be mailed during the first week of June. Contributions are due on *May 12* 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.

From the Editor-in-Chief

Marc Gyssens

As promised, this is another thick issue. While the previous issue may have been a bit one-sided, this issue contains a rich cocktail of articles regarding results obtained by a wide range of observing techniques, even including satellites!

Speaking of other-than-visual observing techniques, many readers may be pleased to hear that the IMO *Council is spending much effort in finding a solution for the unsatisfactory situation that exists in our Organization regarding photographic and radio work. As a first step towards such a solution,* IMO *President Jürgen Rendtel has decided to act as ad-interim director of the Photographic Commission in the hope that once the Commission is running again smoothly, someone will stand up and continue the job. Meanwhile, photographic meteor observers can send their results to Jürgen and be sure they will be used! (And, if you think your photograph is of printable quality, send me a copy as well, maybe I can fit it into this journal...)*

Meanwhile, enjoy this issue.

Supporting Membership

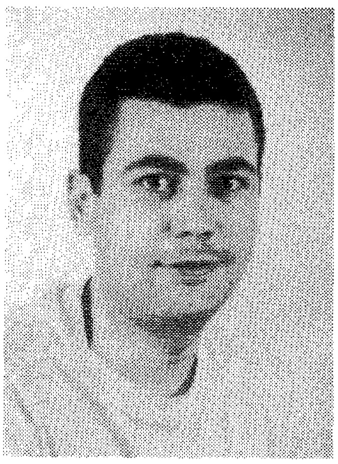
Marc Gyssens and Ina Rendtel

We are glad to see that many members and subscribers accepted our offer to become Supporting Member or Subscriber. Here is the list of all Supporting Members or Subscribers for 1994 at the time of this writing:

> Erich Weber, Mark Vints, Peter Brown, Werner Hasubick, Hans-Georg Schmidt, Per Aldrich, Gotfred M. Kristensen, Jean-Christophe Lernould, Ichiro Hasegawa, Masao Kinoshita, Masahiro Koseki, Kazuhiro Suzuki, Yuko Takeuchi, Yasuhiro Tonomura, Masayoshi Ueda, Yasuo Yabu, Takatsuga Yoshida, Lars Trigve Heen, Marc de Lignie, Lance Bender, Vincent Devore, Gary Kronk, Michael Luciuk, Donald Olson, Philip Roberts, John Paul St. Peter, Richard Taibi.

To all these loyal *WGN* readers, our warmest thanks! We also renew our invitation to all Supporting Members to send in a short description of yourself and your activities plus a photograph for inclusion in *WGN*. In this way, also other meteor workers will get to know you!

Up to now, we received the following description:



Jean-Christophe Lernould

I am living at 1A Im. Henri IV, Bd. Des Rois de France, F-59600 Maubeuge, France. My phone number is +33-27-62-33-71.

I am interested in visual, radio, and telescopic observations, and have been a voting member of the IMO since 1991 (my abbreviation is LERJE). I was born on March 23, 1968. Currently, I am a student of biology.

Letters for WGN

compiled by Marc Gyssens

Meteors, mushrooms, and North-American Indians

Mushrooms seem to inspire the readers of this journal. Below is a comment by Martin Beech concerning Alastair McBeath's reaction (WGN 21:5, p. 225) *to his contribution on the history of meteor astronomy in last year's August issue* (WGN 21:4, pp. 200–202).

Alastair McBeath raised a most interesting point in his recent letter on meteors and mushrooms. I certainly believe that the folkloric record must harbor many more accounts and associations between meteors, fireballs, and terrestrial phenomena. Indeed, I see absolutely no reason to suppose that our ancestors were totally indifferent to meteors and fireballs. They may not have known what they were, but they most certainly saw them. The stories and anecdotes are out there, but we have yet to find them. Not just mushroom-related stories, however, I would also contend that the idea of yearly meteor showers was also known to the vulgar populace long before it was "discovered" by the learned scientists. Proving such an idea would be difficult, but folkloric accounts could strengthen the hypothesis.

In his letter, Alastair referred specifically to the Geaster, literally Earth Star, Mushrooms. This mushroom is appropriately named since its basic form is that of a spherical body (the inner fruiting body) set in a star-like arrangement of rays (the outer skin). Geasters have a world-wide distribution, and are mostly found in woodland regions. As Alastair noted, if there was ever a mushroom that suggested an extraterrestrial origin, the Geaster must assuredly be it. Having said this, however, I know of no folkloric account or anecdote related to the Geaster.

While I was prompted by Alastair's letter to undertake a long survey of the archival literature available to me, I found nothing related to the Geaster. However, in a totally separate project, an interesting link to the Earth Stars did emerge. Peter Brown and I have recently initiated a study of meteor imagery and beliefs in North-American Native culture, and during the course of this investigation, we have discovered that some Native tribes also consider mushrooms to be the remains of shooting stars.

The Blackfeet Indians, for example, give the name Dusty Star to the Puff Ball Mushroom. These mushrooms are commonly found in the prairies, and are supposed by the Blackfeet to be stars (meteors) which have fallen from the night sky. They are called Dusty Stars because they emit a puff of dust (spores) when pressed. The interesting point about the Dusty Stars of the Blackfeet Indians is that the Puff Ball Mushrooms are a close cousin to the Earth Stars. Puff Balls are in fact more commonly known.

I am not entirely sure how much can be made of the apparent human desire to associate meteors and mushrooms. There is now clear evidence, however, that two totally distinct and culturally different societies (North-American Indians and Medieval Europeans) have seen fit to link the appearance of mushrooms with shooting stars.

Martin Beech, March 28, 1994

Frequently Asked Questions on Observing Methods

compiled by Rainer Arlt

How do I measure meteor coordinates on the Atlas Brno? The origin is ambiguous.

Put the chart before you with the chart number in the upper right corner. The origin of the coordinate system is always in the lower left corner, exactly on the *inner* frame of the chart. The y-axis is directed upwards, the x-axis, to the right. Therefore, only positive numbers are valid. Charts 1, 2, 3, 7, 8, 9, 10, 11, and 12 have landscape format (i.e., the longer edges are considered horizontal), charts 4, 5, and 6 have portrait format (i.e., the shorter edges are considered horizontal).

Coordinates are measured in millimeters. There is no need to give fractions of a millimeter; the plotting accuracy is definitely worse than half a millimeter. Small crosses indicate distances of 70 mm. If you make copies of the charts for your own purposes note that most copy machines may change the scale of the charts, even if you selected 100% on the copy panel. Generally, the size of the long axis is altered by 1-3 mm. You can diminish the resulting error of the measurements if you use the small 70-mm crosses as auxiliary origins and add the known offset afterwards.

Although I saw a lot of bright meteors during the night, I did not catch any on a photo. What did I do wrong?

The meteor limiting magnitude of photos is not the same as the limiting magnitude for stars. Meteors move about 2000 times faster (say 10°/s) over the sky than stars. Hence, each particle of the photographic emulsion is exposed to the light about 2000 times less. Consequently, the same blackness associated with a given stars is produced by a meteor which is 2000 times brighter. If the limiting magnitude for stars is $+6$, you should not expect meteors on the photograph fainter than -2. If the meteors are very slowly and have long-persisting trains, you might get meteors up to magnitude 0 at best. Furthermore, the photographed region of the sky with normal lenses ($f = 50$ mm) is much smaller than that of a visual observer. Even if you saw two or three fireballs during the night, they are still likely to miss the camera field on the sky.

Good results can be obtained with fish-eye lenses which cover the whole sky. You will certainly be successful on the night of a major shower's maximum with this equipment. The advantage of photographing the complete sky combines with reasonable limiting magnitudes and sufficient accuracy. The α-Capricornids, κ-Cygnids, and χ-Orionids are known for bright meteors. They move very slowly, making it more probable to leave an image on the photograph.

International Meteor Conference

Belogradchik, Bulgaria, September 22–25, 1994

Registration Form

Each individual participant should fill out a form and return it to Paul Roggemans, Pijnboomstraat 25, B-2800 Mechelen, Belgium, as soon as possible. The deadline is June 30, 1994. Your registration will be guaranteed only after Ina Rendtel has received the minimum pre-payment of 100 DEM. If you wish to participate, but cannot yet decide, simply return this form with the proper option checked to stay on the mailing list for further circulars.

Name: ______________________________ Birth date: ______________

Address: ____

____

____

Phone: ______________ Fax: ______________ E-Mail: ______________

- o wishes to register for the 1994 *IMC* from September 22 to 25;
- o intends to participate, cannot yet register, but wishes to stay on the mailing list.

I intend to travel by ________, together with ______________________________

____

Interested in coordinated traveling? ______________________________

____

For participants interested in car-pooling:

- o I have ___ free places in my car from ______________
- o I need ___ places in a car from ______________

For participants wishing to contribute to the program:

Lecture: ____

Duration: ________min. Required equipment: ______________________________

Workshop or discussion: ______________________________________

Poster presentation: ______________________________ Space: ________ m^2

Either the entire fee of 170 DEM or a pre-payment of at least 100 DEM should be sent to the Treasurer, *Ina Rendtel*, in the same way as your membership/subscription fee. Remember that Ina cannot accept bank checks! People wishing to pay in other currencies (USD, GBP, or JPY) should contact the appropriate *IMO* officer for exchange rates. Participants paying only 100 DEM have to pay the remaining 70 DEM upon arrival in Belogradchik.

Method and date of payment: ______________________ Amount: ____________DEM

Date and signature: ____

The 1994 International Meteor Conference

Belogradchik, Bulgaria, September 22–25

Paul Roggemans

The 13th *International Meteor Conference* will be organized in North-West Bulgaria in a beautiful environment selected by Bulgarian *IMO* members. It will be the first *IMC* in the Balkans, and we hope that it will be easy for people from East European countries to participate. There is still ample opportunity to register! In case you did not yet do so and intend to participate, fill out the registration form quickly and send it to Paul Roggemans (address on inside back cover). For your convenience, we reprint the registration form in this issue.

Remember that the registration fee for the 1994 *IMC* is 170 DEM per person, covering conference participation, overnight accommodation and meals during the *IMC* as well as a copy of the Proceedings. (Drinks, etc. will be paid with cash at the *IMC*.) Upon returning the registration form, at least 100 DEM must be pre-paid to the *IMO* Treasurer, in exactly the same way as you pay for *WGN*. Of course, you may pay the entire fee of 170 DEM with your registration form. Until June 30, 1994, you can cancel your registration, losing only some administration costs on your prepayment.

Call to Radio Observers

Paul Roggemans

Belgian radio observer Maurice De Meyere suggests that all radio amateurs give the *IMO* their BBS code, as this would allow mutual communication via radio. All radio identification codes will be added to the next *"Who is Who?"*. Send all information to the Secretary-General (address on inside back cover).

Visual Observers' Notes: May–June 1994

Jeff Wood

The months of May and June contrast greatly between the northern and the southern hemispheres. In the northern hemisphere there are few showers active and hence overall meteor rates tend to be low. In the southern hemisphere there are quite a few showers to be seen. This together with the ecliptic being high overhead ensures that good rates are seen.

Table 1 lists some of the meteor showers to be seen in May and June 1994. Table 2 shows moonlight and observing conditions. The illuminated part of the Moon is always given for 0^h UT on the date indicated. The dates of the phases of the Moon are also given in UT. Note that the activity period data for the June Bootids and the o-Cetids are uncertain.

The Visual Commission of the *IMO* although requiring data on all streams realizes practical considerations like work, study, family, Moon and weather prevent people from observing regularly on a day by day basis throughout most of the year. With this in mind, it has been decided to encourage everyone who has time to observe to concentrate on a couple of showers per month rather than the whole lot. This means we should be able to get a good set of data on these few rather than sparse data on many showers. The showers chosen for special investigation for the months of May and June are the Scorpio-Sagittarid showers, the η-Aquarids, the o-Cetids, and the June Lyrids.

1. Scorpio-Sagittarids

The Scorpio-Sagittarids encompasses a number of streams that occur in the constellations of Scorpius and Sagittarius during the months of March, April, May, June and July. Named by Dr. C. Hoffmeister during the 1930s, these ecliptic streams are thought to have originated from comet Lexell (1770 II). The Scorpio-Sagittarid showers are noted for greatly varying rates. At times, they are virtually inactive while on other occasions, ZHRs of around 10 have been recorded. The Scorpio-Sagittarid showers are noted for bright colored fireballs and the occasional meteor that produces a persistent train.

As mentioned previously, the Scorpio-Sagittarids consists of a number of sub-streams. The major components whose details are described in Table 1 are the β-Corona Australids, Southern and Northern Ophiuchids, κ-Scorpids, θ-Ophiuchids, α-Scorpids, γ-Sagittarids and the λ-Sagittarids. Since Scorpio-Sagittarid meteors have velocities similar to those of the majority of sporadic meteors, great care needs to be taken in identifying them. Observers should be facing the radiant area and plot all meteors seen.

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

Shower	Activity	Max	Radiant			Drift		V_∞	r
			α	δ	D.	$\Delta\alpha$	$\Delta\delta$		
η-Aquarids	Apr 19–May 28	May 05	336°	−02°	4°	+0°9	+0°4	66	2.7
β-Corona Australids	Apr 23–May 30	May 18	284°	−40°	4°	+0°9	+0°1	45	3.1
Southern Ophiuchids	May 10–May 29	May 20	258°	−24°	5°	+0°9	−0°1	30	2.9
Northern Ophiuchids	Apr 25–May 31	May 13	249°	−14°	5°	+0°9	−0°1	30	2.9
κ-Scorpids	May 04–May 27	May 19	267°	−39°	4°	+0°9	0°0	45	2.8
θ-Ophiuchids	Jun 04–Jul 15	Jun 13	267°	−20°	5°	+0°9	0°0	27	2.8
γ-Sagittarids	May 23–Jun 13	Jun 06	272°	−28°	5°	+0°9	0°0	29	2.9
λ-Sagittarids	Jun 05–Jul 25	Jul 01	276°	−25°	5°	+0°9	0°0	23	2.6
Lyrids (June)	Jun 11–Jun 21	Jun 16	278°	+35°	5°	+0°8	0°0	31	3.0
Bootids (June)	Jun 26–Jun 30	Jun 28	219°	+49°	8°			14	3.0
o-Cetids	May 06–Jun 05	May 15	25°	−04°	5°			36	3.0
α-Scorpids	Mar 26–Jun 04	May 03	246°	−25°	5°	+0°9	−0°1	35	2.5

Table 2 – Moonlight and observing conditions in May–June 1994.

Date	k	Date	k
Friday April 29	0.86−	Friday June 03	0.33−
Friday May 06	0.19−	Friday June 10	0.00+
Friday May 13	0.05+	Friday June 17	0.52+
Friday May 20	0.66+	Friday June 24	1.00−
Friday May 27	0.95−	Friday July 01	0.48−

New Moon:	May 10, June 9, July 8
First Quarter:	May 18, June 16, July 16
Full Moon:	April 25, May 25, June 23
Last Quarter:	May 2, June 1, June 30

2. η-Aquarids

This fine shower is active from April 19 through to May 28 and reaches a maximum ZHR of 50 to 60 meteors per hour on May 3. The η-Aquarids have an unusual activity curve with ZHRs remaining above 35 from about May 3 to May 10. In some years, this period is even greater such as in 1980 when it extended from May 2 to May 15. Another unusual feature of the η-Aquarids is a second maximum on May 8 which has been detected on at least five occasions in the last 15 years. Studies by Z. Sekanina in the USA during the 1960s and 70s involving radio meteors showed that the η-Aquarids consisted of two sub-streams, the "proper" η-Aquarids which reached maximum around May 5 and the so-called Halleyids, which reached maximum on May 8. Since the radiants are very close together, it is impossible to visually separate meteors belonging to these sub-streams, and so naked-eye results show their combined activity.

The η-Aquarids, which where produced by debris from Halley's Comet, are a very spectacular stream, especially for southern hemisphere observers. Unfortunately, because the radiant reaches culmination during daylight hours, the η-Aquarids cannot be viewed in all their glory. Although the radiant is equatorial with a declination of −2°, the seasons are such that it is daylight in much of the northern hemisphere before the radiant can rise more than 20° above the horizon. The southern hemisphere is more favorably placed, and the radiant is able to rise above 50° before sunrise.

The η-Aquarids are best viewed the last couple of hours before sunrise, approximately 3^h45^m to 5^h45^m am local time. They are characteristically fast, yellow in color, and have a train. It is not unusual for these trains to be very persistent, lasting more than 30 seconds. The η-Aquarids produce many brilliant fireballs, the best on record being a magnitude −9 green meteor seen during their 1980 display. This meteor also had a yellow-green train that lasted for some 5 minutes after the meteor itself disappeared from view.

In 1994, the Last-Quarter Moon affects viewing pre-maximum. The maximum and afterwards is virtually moon-free.

3. o-Cetids

This shower was detected by radio astronomers during the 1950s and belongs to the family of daytime showers. For a long time, it was thought that with the radiant reaching culmination during late morning it would be impossible to record meteors visually. However, observations made during the late 1970s by *W.A.M.S.* members demonstrated that during the last hour before twilight prevented viewing, the radiant rose sufficiently in the Southern Hemisphere skies for rates of between 1 and 4 to be recorded. Indeed, not only were rates recorded, but also several visual determinations of the radiant positions were made. These together with the radio determinations form the basis for the crude ephemeris described in Table 3, below.

Table 3 – Radiant positions of the o-Cetids.

Date	α	δ	Date	α	δ
May 08	21°	−06°	May 23	28°	−03°
May 13	24°	−05°	May 28	31°	−01°
May 18	26°	−04°	Jun 02	33°	00°

Southern Hemisphere observers are encouraged to give the o-Cetids particular attention in 1994. With favorable moon conditions before and during maximum together with, hopefully, good weather, a great deal of new knowledge should be uncovered about this shower. Observers should take great care in viewing this stream. They should locate their center of field of view no more than 40° from the radiant and ensure all meteors are plotted.

4. June Lyrids

Over the last few years, only a few scattered observations of this minor shower are known. In most cases, weak or even no activity was reported. Perhaps this shower only produces periodic activity or has been perturbed in such a way that it no longer encounters the Earth.

Nevertheless, with favorable conditions moonwise, there will be a chance to monitor this shower in 1994. Center your field at a distance of about 20° to 40° from the radiant. Plot all possible shower members and carry out shower association taking into account path direction, angular velocity and path length.

Table 4 – Radiant positions of the June Lyrids.

Date	α	δ
Jun 11	274°	+35°
Jun 16	278°	+35°
Jun 21	282°	+35°

5. Theoretical radiant of comet 1983 VII

The orbit of the long period comet 1983 VII approaches the Earth at a minimum distance of 0.003 AU on May 12, yielding a theoretical radiant at $\alpha = 289°$ and $\delta = +44°$ with $V_G = 45.4$ km/s. This radiant is well situated for observers in the Northern Hemisphere. The geocentric velocity as well as the very close approach of the comet's orbit leave a chance that there will be a detectable shower.

The actual radiant position may differ somewhat from the predicted one. To determine it, plot all meteors possibly radiating from an area of about 15° radius around the predicted radiant, fill out a list as for the Aquarid project [1] and send it to the Visual Commission. Using *PosDat* and a radiant analysis program it will be studied whether or not there is an active radiant and its location.

For plotting, the *Gnomonic Atlas Brno 2000.0* is recommended. The field of view should be centered at a distance of about 10° to 30° from the predicted radiant. For observations the time from around May 5 until May 20 are ideal.

6. Final remarks

In those instances where counting is permitted, the meteor's angular velocity should be taken into account. As a courtesy to our new readers, we reprint the relationship between the meteor's angular velocity, height, and distance to the radiant for various values of the stream's geocentric velocity in Table 5.

Reference

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

Table 5 – Angular velocity ($^\circ$/s) as a function of the altitude of the meteor's beginning point h_b and the distance D between the end point and the radiant for various values of a stream's geocentric velocity V_∞. H_b is the altitude of the meteor's beginning point above the Earth's surface.

	$V_\infty = 20$ km/s, $H_b = 100$ km					$V_\infty = 25$ km/s, $H_b = 100$ km				
	$h_b = 10^\circ$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5^\circ$	0.2	0.3	0.6	0.9	1.0	0.2	0.4	0.8	1.1	1.3
10°	0.3	0.7	1.3	1.7	2.0	0.4	0.9	1.6	2.2	2.5
20°	0.7	1.3	2.5	3.4	3.9	0.9	1.7	3.2	4.3	4.9
40°	1.3	2.5	4.7	6.3	7.3	1.6	3.2	5.9	8.0	9.3
60°	1.7	3.4	6.3	8.5	9.8	2.2	4.3	8.0	11	13
90°	2.0	3.9	7.3	9.8	11	2.5	4.9	9.3	13	14

	$V_\infty = 30$ km/s, $H_b = 100$ km					$V_\infty = 35$ km/s, $H_b = 100$ km				
	$h_b = 10^\circ$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5^\circ$	0.3	0.5	1.0	1.4	1.6	0.3	0.6	1.1	1.5	1.7
10°	0.5	1.1	2.0	2.7	3.1	0.6	1.2	2.2	3.0	3.4
20°	1.1	2.1	4.0	5.3	6.2	1.2	2.3	4.3	5.8	6.7
40°	2.0	4.0	7.4	10	12	2.2	4.3	8.2	11	13
60°	2.7	5.3	10	14	16	3.0	5.8	11	15	17
90°	3.1	6.2	12	16	18	3.4	6.7	13	17	20

	$V_\infty = 40$ km/s, $H_b = 100$ km					$V_\infty = 50$ km/s, $H_b = 110$ km				
	$h_b = 10^\circ$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5^\circ$	0.3	0.7	1.3	1.7	2.0	0.4	0.8	1.5	2.0	2.3
10°	0.7	1.4	2.6	3.5	4.0	0.8	1.6	2.9	3.9	4.6
20°	1.4	2.7	5.0	6.8	7.9	1.6	3.1	5.8	7.8	9.0
40°	2.6	5.0	9.5	13	15	2.9	5.8	11	15	17
60°	3.5	6.8	13	17	20	3.9	7.8	15	20	23
90°	4.0	7.9	15	20	23	4.6	9.0	17	23	26

	$V_\infty = 60$ km/s, $H_b = 115$ km					$V_\infty = 66$ km/s, $H_b = 115$ km				
	$h_b = 10^\circ$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5^\circ$	0.5	0.9	1.7	2.3	2.6	0.5	1.0	1.9	2.5	2.9
10°	0.9	1.8	3.4	4.5	5.2	1.0	2.0	3.7	5.0	5.8
20°	1.8	3.5	6.7	9.0	10	2.0	3.9	7.3	10	11
40°	3.7	6.7	13	17	20	3.7	7.3	14	18	21
60°	4.6	9.0	17	23	26	5.0	10	18	25	29
90°	5.3	10	20	26	30	5.8	11	21	29	33

	$V_\infty = 70$ km/s, $H_b = 126$ km				
	$h_b = 10^\circ$	20°	40°	60°	90°
$D = 5^\circ$	0.5	0.9	1.8	2.4	2.8
10°	1.0	1.9	3.6	4.8	5.5
20°	1.9	3.7	7.0	9.4	11
40°	3.6	7.0	13	18	21
60°	4.8	9.4	18	24	28
90°	5.5	11	21	28	32

Photographic Observers' Notes: May–June 1994

Jürgen Rendtel

The determination of radiants and orbits of meteors requires double station photographs. With some assumptions, however, single station photographs may be used to determine radiants. There are at least two conditions which must be fulfilled:

(1) photographs should be taken through a rotating shutter with known frequency; and

(2) the time of the meteor's appearance must be known.

This permits measurement of the apparent trajectory of the meteor and its potential association with known active showers. With the measured angular velocity and the geocentric velocity of the suspected shower, the radiant of the meteor can be calculated with the help of the RADIANT program. Such investigations are of interest in the case of poorly defined radiants, as for example for the near-ecliptic complex, or some high inclination showers to be discussed here later during the year.

In the months of May and June, the center of the ecliptical radiation complex moves from Libra to Sagittarius. The most suitable field centers for photographs of meteors associated with this complex is about 30°–40° east or west of the suspected center (Table 1), if the Moon is not too close to the region (end of May). Observers at northern latitudes should point their cameras at about 10°–20° high declinations.

Prints of at least 10 cm × 15 cm as well as the technical and exposure data of meteor photographs should be sent to Jürgen Rendtel, Gontardstraße 11, D-14471 Potsdam, Germany. Of course, any photographs measured according to the procedure described in the *IMO* monograph *Photographic Astrometry* are welcome as well. Hints for achieving respective photographs can be obtained from the *Photographic Handbook*.

Table 1 – Radiant center of the ecliptical meteor activity in May and June and suggested field centers for the photography of associated meteors. The declination of the field center should be −25° to −35°. Observers at more northern latitudes should choose a field center about 20° north of the ecliptic (not too close to horizon).

Date	Ecliptical radiant		Field centers	
	α	δ	α	α
May 05	236°	−25°	200°	260°
15	243°	−27°	210°	270°
25	251°	−29°	–	–
Jun 04	260°	−30°	230°	290°
14	269°	−30°	240°	300°
24	279°	−28°	–	–
Jul 04	288°	−27°	260°	320°

Telescopic Observers' Notes: May–June 1994

Malcolm J. Currie

The last few months have been very quiet on the observation front, so there is little to report. Chris Hall braved February's cold and made three hours of observations on three nights in February, most of the watches being after midnight, and totaling 30 meteors. A quick intersection analysis ignoring the velocity information shows that six meteors appear to emanate from a 3°-diameter region at $\alpha \approx 139°$ and $\delta \approx +36°$. There was no strong α-Leonid activity. There could also be a radiant near the Sickle of Leo, but it is hard to define as the location almost lies in line with the two field centers used by Chris.

Our computers switched from VAX/VMS to Unix recently. Although my e-mail address is unchanged, there was a period of about a week during late January to early February where incoming non-local e-mail messages were being lost. So if you mailed me around that time and have not received a reply, please mail me again.

Forthcoming events

Even though the nights are growing warmer (for most of us) and meteor activity is gradually increasing, there are many pieces of May and June's telescopic-meteor jigsaw missing. Twilight severely limits the length of meteor watches in the north, so any opportunities to observe should not be missed.

We *believe* that at this time of year ecliptic complexes stretching from Virgo to Sagittarius dominate the shower-meteor flux. However, it would be a mistake just to concentrate on these associations of clustered radiants as we might miss previously unknown showers. A case in point was the θ-Herculids discovered independently by Mark Vints and members of the *Nippon Meteor Society*. The sky is constantly changing; as a familiar shower fades from view, the Earth intersects new or perturbed streams to replace it. Telescopic observing can detect these new showers above the sporadic background more easily than visually. Fields located at $\delta \approx +10°$ (see below for numbers) will enable investigation of both the ecliptic complexes, and any other radiants up to $\delta \approx +40°$. To go further north needs a complementary set of fields, for example charts 43, 46, 47, and 7; or 44, 29, 33 and 7. The first three in each set are separated by about 30° at similar declinations. Field 7 will help to pinpoint the right ascension of any radiant situated between the first three fields. Cycle through a set, changing fields about every 30 minutes.

The *θ-Herculids* are medium-speed meteors associated with Comet P/IRAS-Araki-Alcock, and give observed rates comparable with the sporadic background, and so ranks as one of the strongest telescopic showers. We know it has a compact radiant of diameter of about 1° around $\alpha = 270°$ and $\delta = +37°$. What we do not know, but could measure, are its duration, time of maximum, radiant motion and size throughout the activity period. There is also some disagreement in the radiant position between different observers in different years. Observations in mid-northern latitudes will suffer only partial interference from a waning gibbous moon after May 27; those further south will have more moonlight, but have a longer night. Watches for the following week are highly desirable. Suggested chart pairs are 85 and 111, 62 and 131.

The *η-Aquarid* shower is a prime target for the telescopic observer, as it has multiple maxima and substructure within the radiant, and derives from the P/Halley stream that causes the Orionid display. Thus observations contribute to the Commission's continuing goal to probe the structure of the stream and radiant by plotting meteors and hence to investigate the fascinating comings and goings of the streamlets (see [1] and [2] for more details). The meteors are fast but many leave persistent trains that help to fix the paths, and are a fine sight magnified. Twilight means that the shower can only be observed for a worthwhile period south of latitude 40° N in the few hours before dawn. This year a waning moon interferes up to around May 6. However, the shower of fast meteors, many with persistent trains, continues through the following ten days. One of the maxima—the so-called Halleyids—occurs around May 8 and should be observable. There may be others due to filaments in the stream. Suggested charts are 137 and 163 for northern-hemisphere observers.

Most of the ecliptic complexes mentioned earlier produce a high proportion of faint meteors—rates over half the sporadic background are possible; and they all have moderate speed making them amenable to telescopic study. It is the accuracy of careful telescopic plotting that permits separation of the various components, even with low numbers of meteors. Due to their long duration, at least part of each complex can be seen every year, regardless of the lunar phase. Declining *Virginid* activity continues during May, though the center of activity is in Libra. About 35° east of the Virginid radiants is the more prominent and bifurcated *Ophiuchid* shower. Southern-hemisphere watchers may see rates comparable to the sporadic activity; even from mid-northern latitudes where the radiant elevation is poor, observers can expect to see on average one medium-speed Ophiuchid per three sporadic meteors. The northern component is favorably placed with regard to moonlight. Charts for these showers are (in right-ascension order) 159, 148, 149, 150, 162, 151, and 163. Start to the west of the showers with 159 or 148, and as the night progresses move to fields further east changing after thirty minutes. If you cannot manage more than two watches in a night, it is best not to select adjacent fields, thus 148 and 150 would be satisfactory. Those south of the equator may prefer centers around $\delta = -35°$ in Centaurus, Lupus, and Scorpius.

Moving into June, a complex of radiants in Scorpius and Sagittarius come to the fore. There are few telescopic data on *Scorpio-Sagittarid* showers, principally because the telescopic observers historically have been situated at mid-northern latitudes, and have been prevented by twilight, the radiant elevation, and public examinations. Once again, there is ample opportunity for rewarding observations for those fortunate to reside south of the equator. One obvious aim is to delineate the various constituent branches and to determine their activity periods. Only plotting enables this to be achieved, because of the proximity of the sub-centers. At least three fields should be observed to assist identification of the real radiants from the artifacts. Recommended charts are 161 to 163.

The *June Bootid* shower has virtually disappeared due to perturbations by Jupiter, and was last recorded two decades ago; but given some of the recent surprises in meteor astronomy it is worth looking out for residue from the periphery of the P/Pons-Winnecke stream in late June. If there are signs of life, telescopic observers should detect it promptly as it is noted for a high proportion of faint meteors. One of several suitable pairs of charts are 29 and 85.

References

[1] Currie M.J., "Telescopic Observers' Notes: Nov–Dec 1990", *WGN* 18:5, October 1990, pp. 180–183.

[2] Koschack R., Roggemans P., "The 1990 Orionids", *WGN* 19:4, 1991, pp. 115–130.

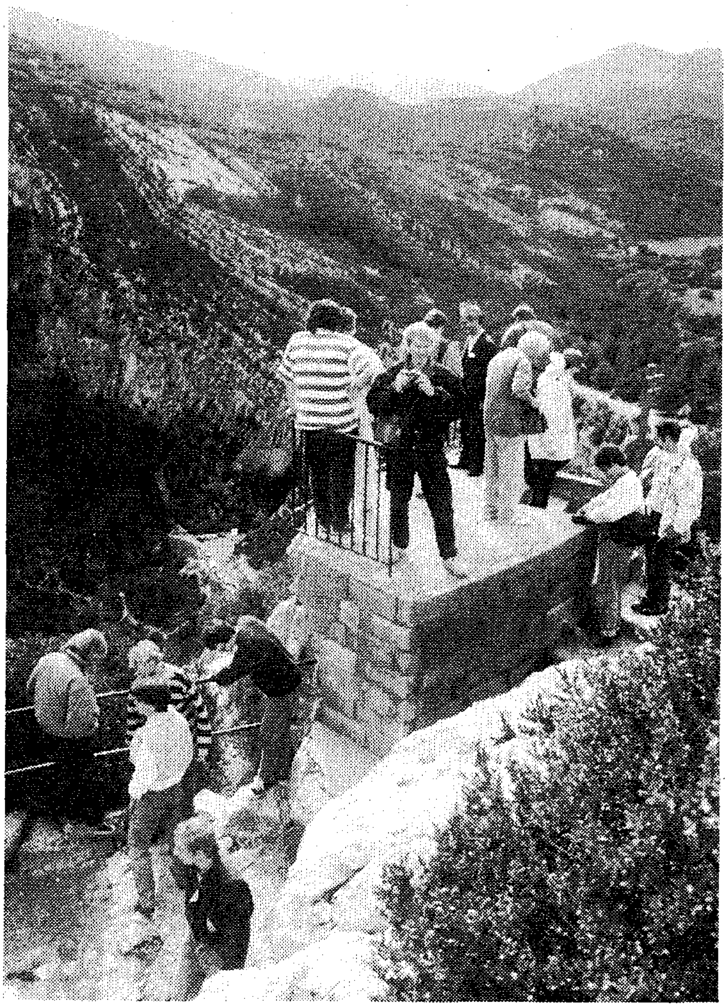
Theoretical Radiants of New and Other Minor Planets

Dirk Artoos

Table 1 – Theoretical radiants of asteroids.

Minor planet	$\lambda_{\odot}$	Date	α	δ	V_{∞}	Distance
1987 KF (5511)	33°95	Apr 27	35°5	−03°6	24 km/s	0.19837 AU
1994 CJ1	42°9	May 03	155°	−07°3	12.2 km/s	0.03373 AU
Anteros (1943)	44°84	May 05	144°7	−46°1	12.4 km/s	0.08656 AU
1988 TA (5704)	51°73	May 12	215°	−21°	16.7 km/s	0.02693 AU
1989 FB (5803)	58°84	May 20	269°	+16°5	15 km/s	0.18422 AU
Xanthus (4544)	59°51	May 24	270°	+16°6	15 km/s	0.18429 AU
1989 JA (5818)	65°33	May 26	237°	+24°4	17 km/s	0.02815 AU
Oljato (2201)	76°75	June 07	78°5	+27°	23 km/s	0.00021 AU
1994 AH2	77°78	Jun 08	88°6	+06°	22 km/s	0.1670 AU
1994 CC	79°68	Jun 10	211°2	−34°	14 km/s	0.01486 AU
Icarus (1566)	83°02	Jun 14	48°	+31°5	31.6 km/s	0.03915 AU
1993 KH	85°5	Jun 18	272°	+13°3	15.6 km/s	0.13819 AU

References: I.A.U. Circulars, M.P.E. Circulars, and E.M.P. 1994.



Looking down into the famous Verdon Canyon during the official excursion at the 1993 *IMC* in Puimichel, Southern France.

Ongoing Meteor Work

Telescopic Results near the 1993 Perseids' Maximum

Malcolm J. Currie

Relatively few telescopic observations were made for the 1993 Perseids. The effective observing time was 18.27 hours totaled by four observers, during which 145 meteors were recorded. No outburst was observed. Analysis of the data implies an abnormally low population index of about 1.6. Only a minimal radiant analysis is possible and this shows the main Perseid telescopic radiant is located at the position of the visual radiant. There is an apparently stronger Perseid radiant at $\alpha = 32.^\circ6$ and $\delta = +61.^\circ7$. However, it should be viewed with some caution since it was only observed from three field centers, and from one of these it was aligned with the main Perseid radiant. There are indications of other radiants in the data. In order of increasing prominence these were as follows: ι-Cassiopeids (from the list of Znojil [22]), which were barely detected above the noise; a new radiant at $\alpha \approx 2^\circ$, $\delta = +74^\circ$; and the 47-Cepheids, κ-Cepheids, and ι-Cepheids [22]. These were not seen by all observers from many fields and so can only be regarded as probable rather than certain radiants.

1. Introduction

The Perseid shower has revealed many surprises in recent years, the most notable being the discovery of a second maximum of increasing flux [1–7,12]. Theoretical modeling [8] supports the suggestion that this was due to material deposited by the parent comet, P/Swift-Tuttle, at its last perihelion passage in 1862 [5,9]. The strong show from this sub-stream in 1992, and the recent return of P/Swift-Tuttle, lead to a wide variety of predictions from the conservative to the fantastic appearing in the "literature." These predictions certainly sparked great interest in meteors in general, and more specifically, the Telescopic Commission received many enquiries from people wishing to observe the Perseids telescopically, even though the Perseids do not normally offer a telescopic spectacle.

Telescopic data complements the visual and photographic as they can assess the flux density of low-mass particles in the new sub-stream. The relative numbers of different-sized particles is a fundamental parameter needed for theoretical modeling of stream formation and evolution [10]. The lower observed meteor rate and small field of view enable accurate plotting and hence the investigation of radiant properties; also they permit other showers in the vicinity to be studied simultaneously.

The Telescopic Commission circulated material to the various interested parties, including instructions of what to do if there were a high frequency of telescopic meteors, charts, and a list of goals. The main aims were as follows:

- to determine the radiant location, and to see if the new material radiated from the normal position, after allowance for daily motion;
- to see if there were multiple radiants during the few days around peak activity as have been claimed (for example, [11]), and whether or not the radiant changes size through the maximum [12];
- to determine the population index through the period; and
- to find which other radiants were active in the Perseus region.

In the unlikely event of a strong Perseid return, observers were instructed to concentrate on either plotting (for small apparent fields of view) or counting (wide fields). Counting would be useful to compile a rate curve whose shape we could compare with the visual ZHR profile.

Mark Vints [13] had selected an arc of field centers to the north of the Perseid radiant and about 15° distant. The selection avoided occlusions from the expected Perseid radiant, and if all were used through the night, would reduce the prominence of artifacts appearing in the radiant analysis. These fields were adopted and integrated into the standard chart sets.

2. Observations

Buoyed by claims for a possible strong visual Perseid shower in 1993, few observers wanted the spectacle to be restricted by the small field of view of a telescope or binocular. Those in the Telescopic Commission who did and were blessed with some clear skies are

Gordan Bartolić (BARGO), Malcolm Currie (CURMA), Vanja Rodiger (RODVA), and Mark Vints (VINMA).

Several others were thwarted by cloud. For each observer, Table 1 lists the instrument and its field of view, and, for each night, effective observing time (T_{eff}), the total number of meteors recorded, and the number of Perseids seen. The totals were $T_{\text{eff}} = 18.27$ hours, and 145 meteors of which 27.5 were Perseids. The shower assignments are based upon a preliminary tracing analysis without recourse to the velocity information. This is adequate given problems with the velocity scale (described later), and the rough calculation of population index derived below.

Table 1 – Summary of telescopic observations during the 1993 Perseid peak.

Obs	Instrument	Field	1993 August					
			09-10	10-11	11-12	12-13	13-14	14-15
BARGO	10 × 75	5°5			3.80 13 5P	1.23 6 2P		
CURMA	19.5 × 127	2°6				3.31 32 4.5P		
RODVA	7 × 50	6°5			1.68 7 3.5P	1.85 11 6P	1.68 10 1P	0.43 3 0P
VINMA	10 × 50	6°2	0.83 11 1P	0.13 2 0P	3.33 50 4.5P			

3. Population index

It is readily apparent that there was no enhanced Perseid activity at telescopic magnitudes. On the contrary, the display was less impressive than a few years ago, according to Mark Vints [13]. The number of data preclude an accurate estimate of the population index, r. However, that is not going to stop us from estimating it crudely for the night of August 11-12. There were 70 telescopic meteors recorded in all, 13 of which were Perseids. Thus the ratio of the number of Perseids to sporadics is approximately 0.23. If we allow for the average radiant altitude during the observations, this ratio increases to 0.30. At the same time ($\lambda_{\odot} = 139°35$), the visual ratio was about 7 [14]. Thus the visual Perseid shower was 23 times more prominent than the telescopic one. Now the difference in mean meteor magnitudes of the two ratios was about 5.5, after correcting the telescopic-meteor brightnesses for the apparent angular velocity using Znojil's formula [15]. Using a typical sporadic population index of 2.9 [16] results in $r \approx 1.6$.

This calculation makes a number of assumptions such as the sporadic population index is constant over the magnitude range, and the perceptions, limiting magnitudes, and instruments of the different observers are the same. Given that it is only a ballpark estimate, it agrees surprisingly well with the visual $r \approx 1.8$ at the same time [14]. This finding is also in good agreement with the 1988 Czechoslovakian results [17], where the population index was determined far more accurately than above; they obtained $r = 1.58 \pm 0.13$. The uncertainty in the derived r prevents any conclusion regarding a change of r with magnitude.

4. Radiant analysis

We measured the Cartesian coordinates of the start and end points of the plotted meteors, and converted these to equatorial positions using standard astrometric methods. The typical measuring error converted to angular distance was negligible compared with typical plotting errors. To perform a radiant analysis equatorial co-ordinates and other parameters for each meteor were first stored in POSDAT [18] format for use by the RADIANT software [19].

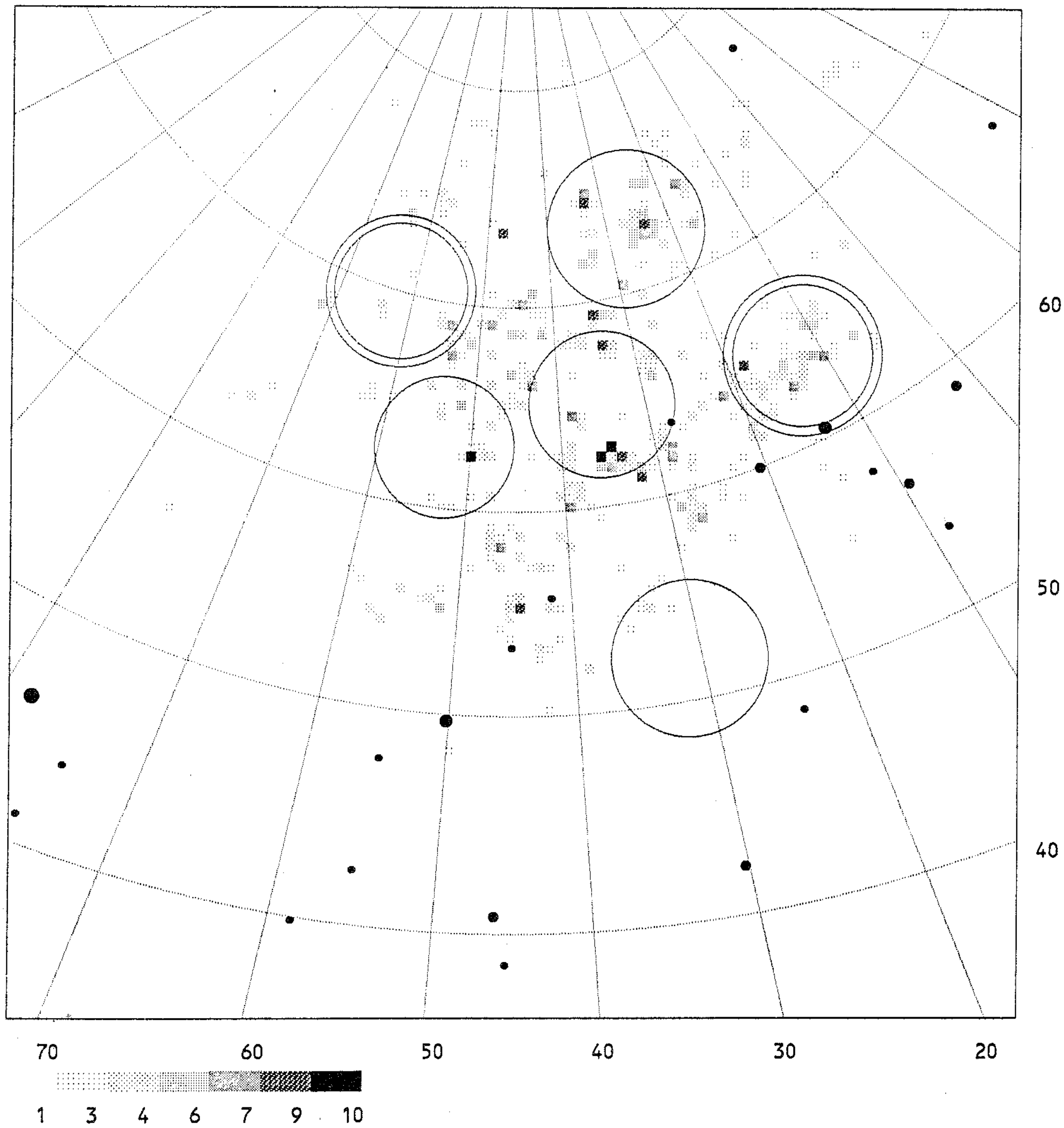


Figure 1 – An intersection analysis for all observers and data during the period August 9-10 to 14-15, 1993. In total, 1562 intersections are present. Angular velocities are not considered. The minimum intersection angle is 30°. The circles show the locations and sizes of the telescopic fields. On this and subsequent figures, the reference solar longitude is $\lambda_\odot = 139^\circ\!.9$ (eq. 2000.0), the daily motion is $0^\circ\!.69$ per day, scale corrections and zenithal attraction are applied, the assumed geocentric velocity is 65km/s, and stars brighter than magnitude +4 are marked.

Meteor paths are traced backwards over a range of a great circle. The length and location of this prolongation are defined by the angular and geocentric velocities of the meteors, but RADIANT also allows the minimum and maximum distances to be specified. For this work, the minimum distance was twice the apparent path length; twice rather than the normal once because telescopic observers tend to underestimate the true path length of meteors, and at present RADIANT does not make an allowance for meteors that begin and/or end outside the observer's field of view. The maximum distance was 50°.

For the analysis, RADIANT divides a nominated region of the sky into bins (pixels). It uses gnomonic projection so that a plotted meteor path is a straight line. RADIANT then sums in each bin the counts or probabilities computed from the prolongations, thus forming an image. We used a 100 × 100-pixel grid with $0^\circ\!.5$ square bins.

In this paper, we calculated our gnomonic maps in one of two ways.

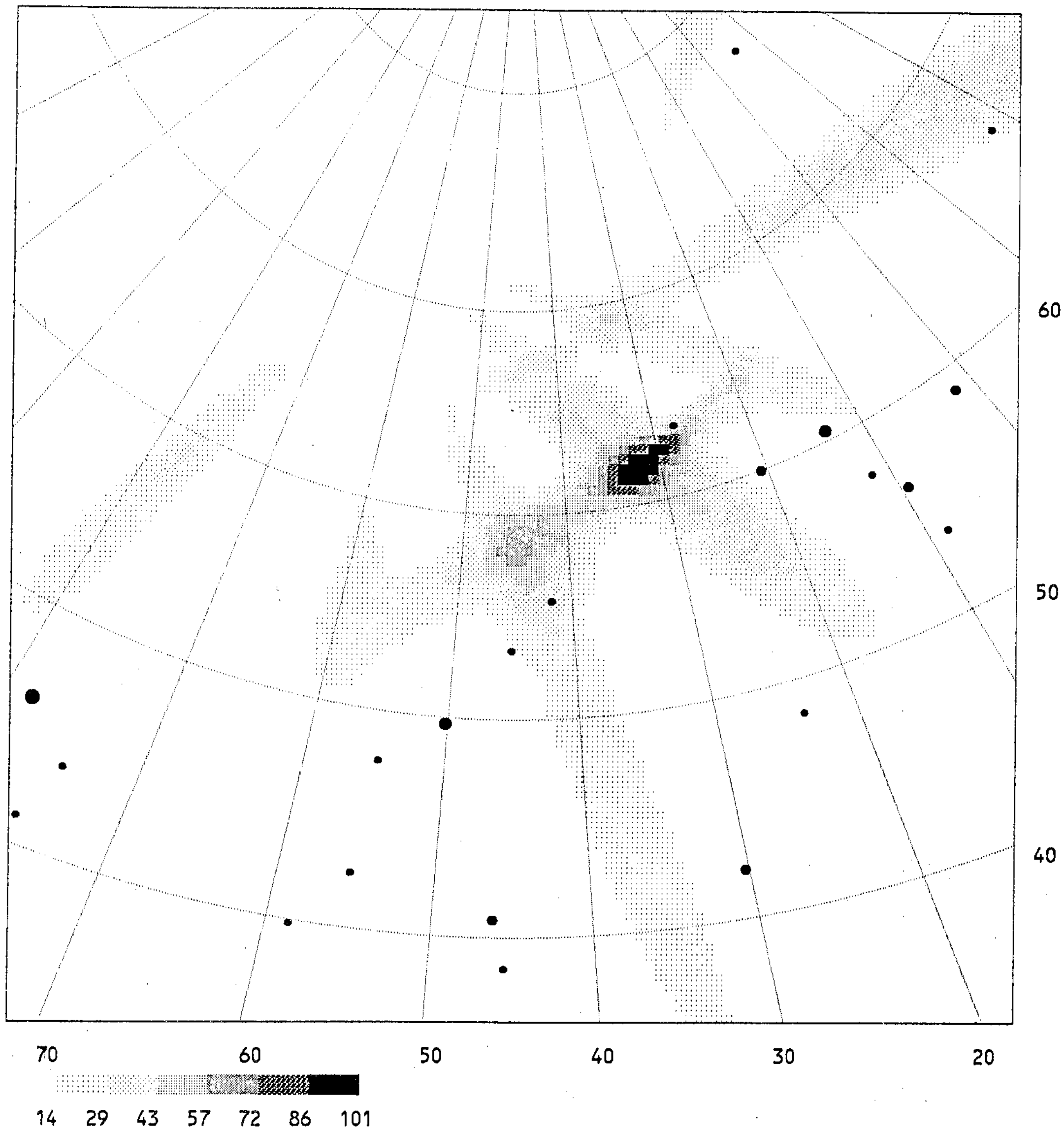


Figure 2 – A probability plot for observers BARGO and RODVA for August 11-12, 1993. Meteors in the slowest three speed classes were excluded. In total, 17 meteors are plotted.

First is the intersection plot. The intensity of each bin is the sum of the number of intersections of meteor prolongations within that bin. It can often reveal finer detail than the more-common second type that we used—the probability plot—and does not require velocity information. The observational errors associated with the plotting of a meteor coupled with the velocity information gives a pear-shaped distribution around the nominal path, and it is these probabilities that are integrated to form the map of radiants in the second type of plot shown. All the figures in this paper have zenithal attraction and scale corrections applied by RADIANT.

5. Perseid radiant

An initial analysis using the standard velocity code to degrees per second produced no radiants in the Perseus region. Upon inspection of the histogram of speed codes of BARGO and RODVA—two new and relatively inexperienced observers—revealed a strong bias towards high velocities. This is probably due to the fact that a slow telescopic meteor is like a fast visual one; it takes time to see the full range of telescopic angular speeds and hence get a balanced distribution of speeds.

A simple intersection plot without using the velocities, as shown in Figure 1, reveals the Perseid radiant, but is confused by noise and artifacts especially near the observing fields. These fields are indicated by circles in Figure 1. Note that not all of the planned fields were used, and BARGO and RODVA adopted two other centers less than 10° from the nominal Perseid radiant.

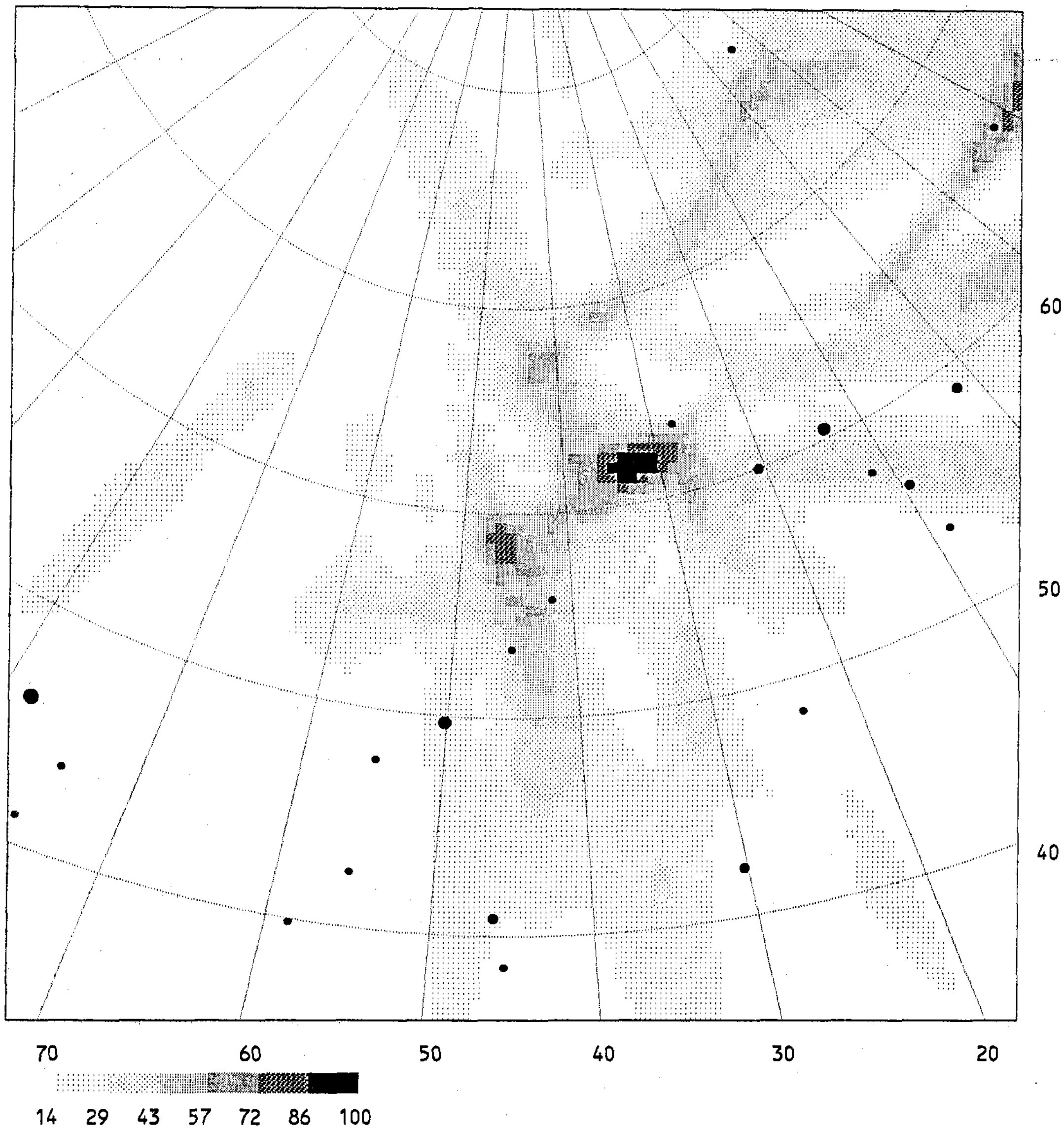


Figure 3 – A probability plot for observers BARGO and RODVA for August 11-12 to 14-15, 1993. Meteors in the slowest three speed classes were excluded. In total, 43 meteors are plotted.

To improve matters we performed a self-calibration. RADIANT scales all the speed codes by an adjustable constant. For a series of values for this scaling constant, we examined the radiant distribution using the probability mode of RADIANT; the optimum value was deemed to be where the Perseid radiant became most prominent. Note that for many scaling values no radiants were visible and so this test is quite powerful. Such calibrations were performed for BARGO and RODVA together, and for VINMA, giving 1.4 and 1.8, respectively. This is not as accurate as can be achieved with larger data sets such as for the 1990 Geminids [20], where a lookup table of speed code to degrees per second is possible and desirable.

Figure 2 shows the probability distribution for meteors seen on August 11-12 ($\lambda_\odot = 139^\circ\!.2$–$139^\circ\!.6$) by BARGO and RODVA from 20 meteors. The orientation errors used were those for shower meteors as derived for the Geminids [21]. Whilest these may be underestimated for the inexperienced pair of observers and for the faster Perseids, we felt that they were more realistic than the visual errors as defaulted in RADIANT. The main Perseid radiant is visible at $\alpha = 45^\circ$ and $\delta = +58^\circ$; it is a 5.8σ detection. Figure 3 plots all the data of BARGO and RODVA. The Perseid radiant is situated at $\alpha = 45^\circ\!.2$ and $\delta = +58^\circ\!.2$ and is detected at 4.4σ. Also visible in Figure 2 is a stronger source at $\alpha = 32^\circ\!.6$ and $\delta = +61^\circ\!.7$—an 8.5σ detection. Is this real or an artifact?

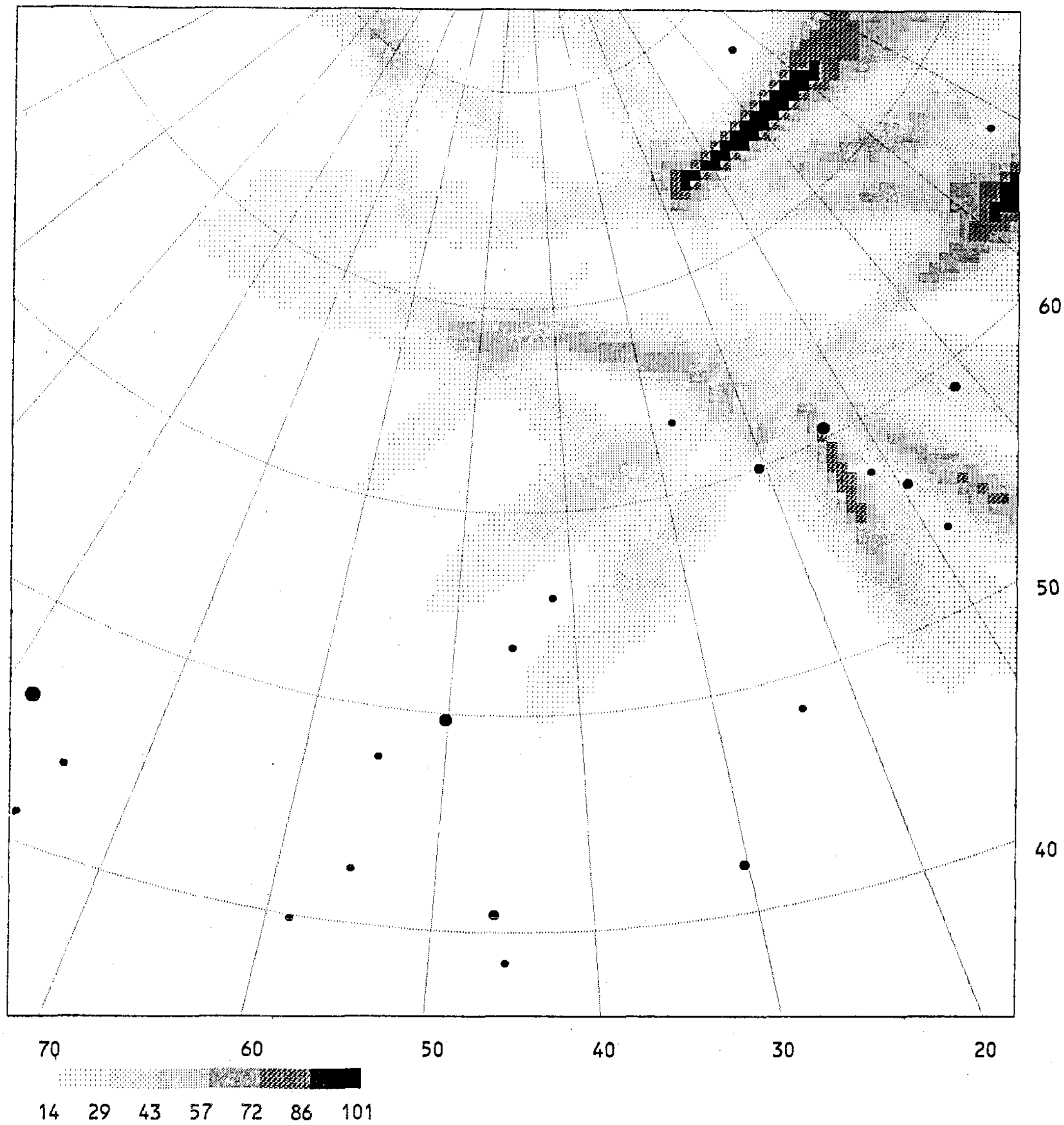


Figure 4 – A probability plot for observer VINMA for August 11-12, 1993. Meteors in the slowest three speed classes were excluded. In total, 39 meteors are plotted.

Certainly, the western-most field and the two radiants are aligned, so many of the meteors possibly emanating from the secondary radiant have a high probability of being from the standard Perseid radiant. When we initially plotted likely Perseids for a report at the 1993 *IMC*, this revealed that many of the extrapolated trails from the western-most field crossed at these coordinates rather than the normal Perseid location. Meteors apparently emanating from this position were observed from three fields (compared to five fields for the standard Perseid radiant).

A critical test is to see if this secondary radiant was visible by VINMA. Figure 4 shows VINMA's data for the same night. The secondary radiant is present but not the main Perseid radiant. So the secondary radiant looks highly plausible. Adjusting VINMA's speed scale factor to as high as 2.3 fails to make this radiant disappear from the plots, though it is much weaker. The radiant is clearly present on August 12-13, so it is unlikely to be associate solely with the new material. There are insufficient data to detect a difference in the mean magnitudes of the meteors from the two radiants, and for most meteors observed in the western-most field their origin is ambiguous due to the alignment. Examining maps made with different geocentric velocities reveals that the secondary radiant is most prominent at $V_\infty \approx 65$ km/s. This lends weight to the hypothesis that the secondary radiant is associated with the Perseids. Note, however, bias from the self-calibration may partly explain this finding.

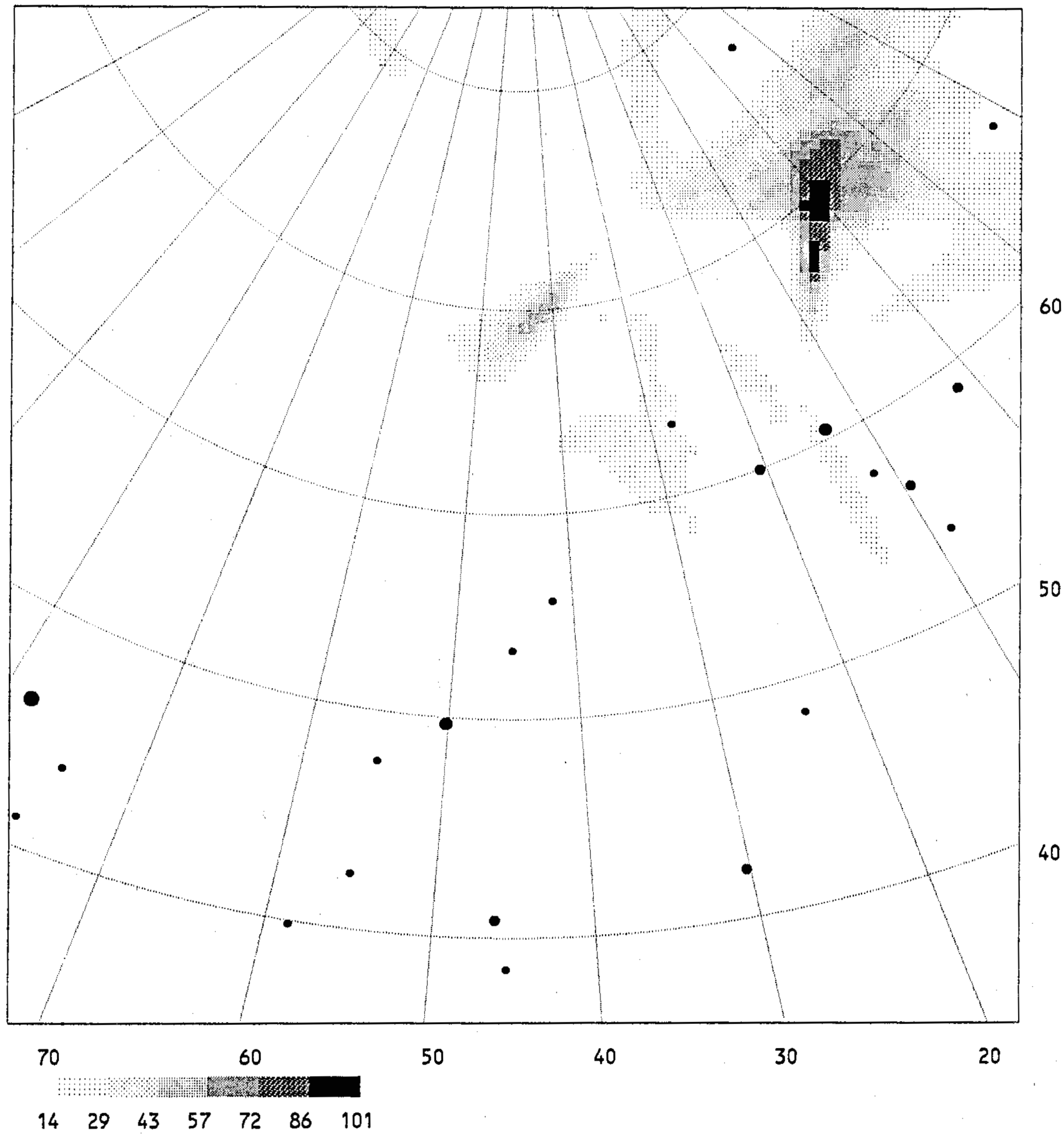


Figure 5 – A probability plot for observer **VINMA** for August 9-10 to 11-12, 1993. Meteors in the fastest three speed classes were excluded. In total, 34 meteors are plotted.

There is no obvious correspondence with this putative radiant and Znojil's list of telescopic showers of $\lambda_\odot = 120°–148°$ [22] based upon data taken during 1966–1973, the nearest being the ι-Cassiopeids some 6° to the north. This possible association is further weakened because in Figures 3 and 4, and other plots not shown, there is some indication of a very weak concentration from the location of the ι-Cassiopeids. The selection of fields hinders identification of this particular shower. To summarize, we feel that the evidence is appealing but far from conclusive, and it is unfortunate that the Telescopic Commission did not receive more data, so we could decide upon the existence of this secondary radiant one way or the other.

The small number of meteors recorded coupled with the uncertainties of the speed calibration makes it difficult to say anything of the radiant sizes, let alone if they change. The main Perseid radiant has a nominal full width at half maximum (FWHM) of 3.°7 and the secondary radiant of 3.°5. For our small dataset these dimensions are probably dominated by the plotting errors.

6. Other radiants?

Figure 5 is the co-added radiant plot for August 11-12. Another strong source appears to be $\alpha \approx 0°$ and $\delta = +74.°5$, some 4.1σ times the noise. We shall call it PR1 (possible radiant one) for convenience.

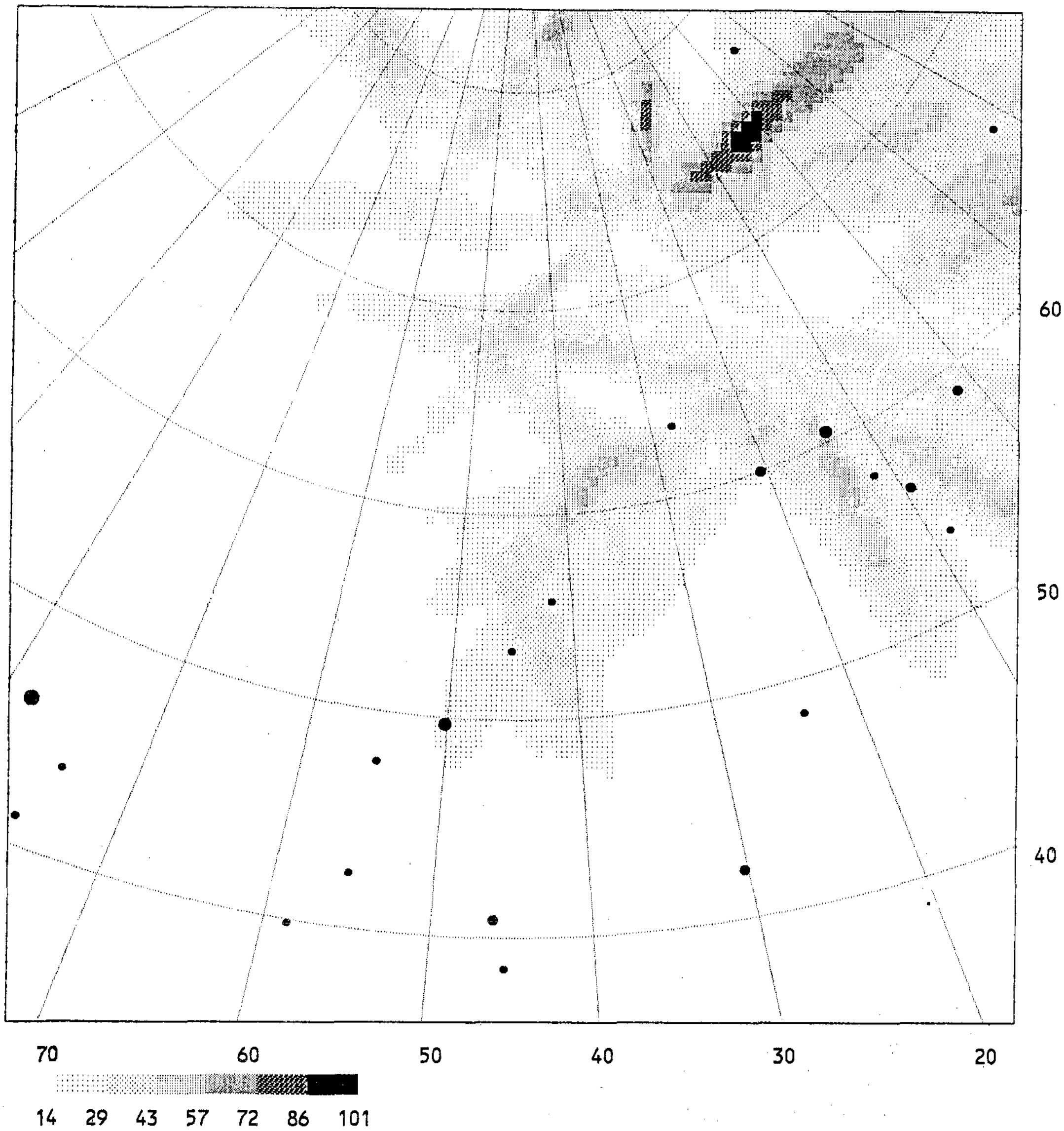


Figure 6 – A probability plot for all observers and all nights (August 9-10 to 14-15, 1993). In total, 102 meteors are plotted.

The right ascension of PR1 is not well determined from VINMA's meteors. The Croatian results in Figure 3 suggest $\alpha = 358°$. The combined plot for all observers (Figure 6) gives $\alpha = 3°$ at 5.6σ. Note that PR1 is seen from three field centers. Restricting the higher velocity meteors (more than 6° per second) reveals an even stronger concentration at $\alpha \approx 0°$ and $\delta = +70°$ (PR2) in VINMA's data (see Figure 6). However, nothing is visible at this location in the plots for the other observers, though this may be due to different observing periods; the overlap is only for August 11-12. This analysis was performed with the Perseid geocentric velocity and daily motion. Now there is no reason to suppose that these radiants have this velocity or daily motion. Indeed, lower velocities might produce quite different conclusions.

Therefore we mapped the distributions using 20, 35, 40, 50, and 65 km/s geocentric velocities, all with a daily motion of 1°0, but with no angular-speed constraint. In VINMA's data, PR2 is apparent for velocities above 35 km/s, and is most prominent at $V_\infty \approx 50$ km/s. For the other observers, PR1 is clearest at $V_\infty \approx 65$ km/s. The maps also revealed another source at $\alpha = 34°$ and $\delta = +82°$, most prominent for $V_\infty \approx 50$ km/s at 5.4σ in the BARGO and RODVA data. It was not observed by VINMA. This radiant could be the 47-Cepheids of Znojil [22]. He notes that it has a relatively high fraction of faint meteors. The night of maximum in 1993 was August 11-12. Some of the meteors used to form PR1 and 47-Cepheid radiants might originate from another, more diffuse radiant at $\alpha \approx 290°$ and $\delta = +81.°5$. It is probably the κ-Cepheids of Znojil [22] and has $V_\infty \approx 35$ km/s. The geometry and lack of accurate velocity data gives ambiguities of shower association for these radiants.[1] Looking at the data carefully suggests that all three are present, though somewhat weaker than it appears from the optimum geocentric velocities.

There is no shower in Znojil's list [22] that corresponds to PR1. PR2 might be the ι-Cepheids. Znojil's results suggest that this shower is not present after $\lambda_\odot = 138.°3$. It is apparent from Figure 4 and from a map of pre-August 11-12 data that most of the signal arises before $\lambda_\odot = 139°$. This would explain why this radiant was observed only by VINMA.

The reader should note that some of the weak apparent radiants found above may be due to spurious detections in the noise, or observer bias. If real, they may arise due to fluctuations in shower activity from year to year, and can only be detected in their stronger returns; or made visible when Poissonian statistics brings them above the background. Znojil notes that some showers are seen only in one year, whilest others are seen in several years. A similar finding arose from analyses of *BAA* and *IMO* telescopic data seen during July and August, 1988–1990 [23,24]. This emphasizes the need for monitoring at every opportunity. Given the prominence of PR1, it is likely to be a real shower, but was not visible or present two decades earlier. A search of other pre-1993 data should be made; it might confirm the reality of this and the other supposed showers found in this study.

To conclude, the case for these radiants is far from proven, and more data are required.

Acknowledgments

I should like to thank the observers who contributed their telescopic data quickly, and resisted the temptation of the visual spectacle. Thanks also go to Rainer Arlt for responding rapidly to my many suggestions and criticisms of RADIANT.

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Telescopic Meteor Radiants in July 1982

David Konečný

During the 1982 observation camp, 146 meteors were well recorded by more than one station. For each meteor of this set, height, radiant, magnitude, and possible stream membership were evaluated. Four new meteor streams were found and the activity of some known streams was confirmed. Some information about the distribution of sporadic meteor radiants was also obtained.

Introduction

You may know the problem of Czech and Slovak amateur meteor astronomy. In the past decades, large meteor observational camps were held every year. Tens of observers watched with 10×80 binoculars and plotted thousands of meteors during a fortnight in such a camp. They also wrote their data into standard forms. The forms have been then deposited at the Brno Observatory and Planetarium and waiting for processing—until today, in many cases.

Three years ago I decided to evaluate some of these data. I chose the data from the 1982 camp, which was the first one of a large three-year project of observing meteors from three stations. The observation took place in central Slovakia, east of the town of Zvolen. The three stations were some 30 km from each other. In the first year, 31 participants observed from July 15 to 26. They made 4567 records of meteors.

I am afraid that very different observing conditions between the stations due to a large amount of dust in the atmosphere and heights above sea level caused the numbers of meteors observed at particular stations to differ greatly (1325 versus 2912 versus 330); for this reason the number of jointly observed meteors was lower than it could have been. The positions of the stations, their relative distances, and azimuths of the direction of their connecting lines are shown in Tables 1 and 2:

Table 1 – Observing stations.

Nr	Location	Longitude	Latitude	Height
1	Gortva	20°00′ E	48°18′ N	280 m
2	Borovina	19°43′ E	48°33′ N	900 m
3	Činčurákova vin.	19°32′ E	48°15′ N	290 m

Table 2 – Combinations of stations.

Combination	Distance	Azimuth
1 - 2	34.0 km	323°
1 - 3	34.6 km	261°
2 - 3	35.1 km	203°

The first two stations were used as references; the direction to the third station was orthogonal to the line connecting the reference stations. Three fields at the same elevation above the horizon and at various azimuths were monitored from each of the stations. This was done in such a way that parts of the fields were mutually overlapping. The middle of these fields was aimed at a given point of reference in the atmosphere. The third station served as a subsidiary one. Observers at the third station watched in one field only aimed directly at this point (it was occupied by fewer observers). The observing fields were aimed to the area of the northern toroidal radiant source. In Table 3, their coordinates are given in the first equatorial system.

Table 3 – Positions of the observing fields.

Station	1			2			3
Field	1	2	3	4	5	6	7
Hour angle Declination	−60°.5 +68°.1	−59°.4 +66°.1	−58°.5 +64°.2	−54°.7 +50°.8	−54°.3 +48°.8	−54°.0 +46°.8	−75°.7 +54°.4

The whole observing project was part of summer meteor observing in three azimuths, each spread 120° apart.

My evaluation of these data had three basic parts: finding the standard deviations of individual observers, calculating the radiants and heights of meteors, and identifying streams and sporadic meteors. For the first two parts, there was a large software system written by Vladimír Znojil. However, it was not simple to use, as I was the first user excepting the original author. In all my work, and especially in its third part, I was led or advised by Vladimír Znojil (who was also the author of the whole research project).

In this way, however, the majority of records were not used at all, as meteors with just one record were not processed. There is certainly much information in these single-station records, but the necessary software to process them is not yet available.

1. Accuracy of meteor plots

The standard deviations were determined from the deviations of plots of the same meteors. From the pairs of plots, standard deviations were computed for individual pairs of observers. The probable values of errors made by individual observers were calculated from them. Furthermore, dependencies on some parameters of meteors (quality, length, brightness) were estimated.

Table 4 shows for each observer the number of observing nights, the effective observing time, the number of records, and hourly rates HR. Then, the standard deviation P of the position angle and d of the transversal shift is given.

Table 4 – Participating observers.

Name	Nights	$T_{\rm eff}$	Records	HR	P	d
Bílek Vlastimil	9	32^h29	351	10.9	$6^{\circ}5$	37′
Glac Luboš	7	23^h16	111	4.8	$7^{\circ}9$	19′
Holček Ondřej	3	12^h69	17	1.3	$22^{\circ}5$	39′
Homola Vladimír	7	24^h96	103	4.1	$9^{\circ}6$	19′
Kessler Pavel	6	$14^h.18$	42	3.0	$10^{\circ}3$	22′
Kesslerová Nad'a	7	26^h31	96	3.6	$15^{\circ}0$	34′
Kováčik Pavol	6	22^h83	72	3.2	$11^{\circ}1$	19′
Kročka Michal	8	24^h75	183	7.4	$8^{\circ}8$	28′
Málek Jan	7	17^h22	131	7.6	$16^{\circ}2$	47′
Míč Boris	8	27^h13	99	3.6	$10^{\circ}7$	17′
Míček Ivo	7	24^h61	146	5.9	$11^{\circ}6$	35′
Mihalkovič Marek	8	28^h91	112	3.9	$9^{\circ}9$	40′
Mrázek Jan	5	17^h40	76	$4^{\circ}4$	$19^{\circ}1$	46′
Novák Pavel	8	25^h99	292	11.2	$13^{\circ}0$	46′
Ondra Leoš	10	33^h18	294	8.9	$12^{\circ}8$	46′
Peřestý Radek	1	1^h37	10	07.3	$11^{\circ}0$	30′
Polloczek Robert	1	1^h68	18	10.7	$14^{\circ}0$	45′
Rapavý Pavol	7	23^h47	92	3.9	$12^{\circ}7$	25′
Šaloun Petr	7	24^h34	150	6.2	$8^{\circ}5$	17′
Šilhán Jindřich	9	28^h92	298	10.3	$17^{\circ}7$	37′
Škvarka Juraj	8	26^h56	164	6.2	$17^{\circ}6$	36′
Tomšík Jiří	8	18^h55	22	01.2	$10^{\circ}5$	35′
Valičová Ivana	9	28^h99	369	12.7	$15^{\circ}2$	37′
Vejchoda Igor	8	28^h63	146	$5^{\circ}1$	$12^{\circ}8$	40′
Wudia Milan	7	13^h63	10	0.7	$6^{\circ}5$	32′
Zimnikoval Peter	6	16^h65	19	1.1	$6^{\circ}0$	25′
Zindulka Ondřej	2	7^h00	42	6.0	$11^{\circ}6$	64′
Znášik Miroslav	6	13^h07	30	2.3	$15^{\circ}7$	46′
Znojil Vladimír	9	27^h69	367	13.7	$9^{\circ}7$	27′
Žižka Jan	10	32^h47	490	15.1	$13^{\circ}0$	42′

The results in Table 4 were needed for the next step. For calculating the radiants and heights, however, the above-mentioned more detailed estimation of standard deviations (dependent on the properties of the meteors) were employed.

2. Radiants and heights

The radiants and heights of meteors can be calculated only for the rare meteors that were detected from at least two stations. In total, 149 meteors were recorded from more than one station, and calculations were possible for 146 of these.

What were the typical properties of a meteor belonging to this set? The mean magnitude was about 7.5, the middle of the trail was 90 ± 6 km high, and it was 12 km long. The uncertainty in radiant determination is about 10° in right ascension and 18° in declination for an average meteor.

3. Streams

From the set of 146 meteors, I have selected 42 which apparently belonged to some streams. Their observed properties (mentioning also the results of the preceding studies by Vladimír Znojil), are as follows.

- *β-Lacertids:* The stream included mostly faint meteors. In 1968 it was very apparent, in other years its activity was low. The activity in 1982 was very high again, but not as great as in 1968.
- *α-Cassiopeids:* A relatively strong stream, active during the entire campaign. It included both faint and bright meteors; the bias toward the faint ones was not so apparent as in previous years.
- *β-Cassiopeids:* Faint meteors dominated this stream. In prior years, there were many bright meteors.
- *ι-Cepheids:* This stream was very faint. It was detected by the preceding observation camps as well, but its activity was always very low.
- *δ-Aquarids:* The maximum of faint meteors should come later than that of bright meteors. I identified only four meteors of this stream, of magnitude about 5–6.
- *π-Sagittarids:* This stream was active mostly at the beginning of the period. Associated meteors were relatively bright.
- *γ-Librids:* This stream gave mostly bright meteors. The α-Serpentids and γ-Librids are probably two parts of the same stream, which differ only by the ecliptical latitude of radiants. This phenomenon is well-known for several other streams (such as Taurids, δ-Aquarids, χ-Orionids, and β-Perseids). These two streams are probably identical to the stream 37-μ-Serpentids given in the fireball stream catalogue of Terentjeva [1]. This shower's activity period is given as July 3–31, and its radiant position as $\alpha = 232°$ and $\delta = -4°$.
- *α-Serpentids:* The meteors of this stream were mostly of magnitude 7.
- *λ- Andromedids:* The stream was active generally at the end of the period. It had very faint meteors. It was not detected by previous observing campaigns.

Table 5 summarizes the data. The main contribution of this part of my work was finding four new meteor streams. They were named λ-Andromedids, α-Serpentids, γ-Librids, and π-Sagittarids.

Table 5 – Data on the streams detected during the 1982 campaign.

Stream	$\lambda_{\odot,\mathrm{beg}}$	$\lambda_{\odot,\mathrm{max}}$	$\lambda_{\odot,\mathrm{end}}$	α	δ	Met	$\overline{m}$
β-Lacertids	114°0	117°4	120°7	329°	+49°	6	7.6
α-Cassiopeids	114°1	117°3	120°7	6°	+55°	8	6.6
β-Cassiopeids	114°0	118°1	122°6	348°	+60°	4	8.1
ι-Cepheids	116°9	119°5	122°6	330°	+64°	4	7.4
δ-Aquarids	115°1	117°9	120°8	336°	+08°	4	5.3
π-Sagittarids	114°1	115°3	116°0	285°	−29°	4	6.7
γ-Librids	114°9	117°2	120°0	235°	−18°	4	6.1
α-Serpentids	115°0	117°4	120°7	232°	+09°	4	7.1
λ-Andromedids	117°9	121°2	122°6	349°	+50°	4	8.5

The activity of sporadic meteors was also studied. Some sporadic meteors belonged to the so-called sporadic streams. The most apparent was the Toroidal Stream.

Observing just one part of the sky is not optimal for studying the all-sky distribution of radiants. Sensitivity is greater in the part of the sky where telescopes are directed. In 1982, the toroidal stream was twice as strong as the antihelion stream. The observing camps in the following years, 1983 and 1984, observed different parts of the sky: their azimuths differed by 120°. After processing the data from these camps, we will be able to make conclusions about the ratios of the activity of the different sporadic sources.

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A New Minor Shower Belonging to the Coma Berenicid Complex?

Kazuhiro Suzuki, Toshimichi Akebo, Satoru Suzuki, and Takatsugu Yoshida

A new faint TV meteor shower radiating from near Coma Berenices was detected by multi-station TV observation in January, 1992, 1993, and 1994. The seven orbits of meteoroids belonging to this stream that have been determined are somewhat different from the orbit of the Coma Berenicids reported by Cook [1]. Therefore, the new stream appears to be a southern branch of the Coma Berenicid Complex.

Multi-station TV meteor observations using image intensifiers were carried out in January, 1992, 1993, and 1994. As a result, 7 meteors (3 on January 15, 1994, 2 on January 16, 1994, 1 on January 11, 1992, and 1 on January 22, 1993) probably belonging to a new minor shower were recorded simultaneously on VHS video tapes at two stations of the Damine Meteor Observatory: Toyokawa ($\lambda = 137°19'23''.9$ E, $\varphi = 34°48'44''.4$ N, $h = 10$ m) and Okazaki ($\lambda = 137°13'28''.4$ E, $\varphi = 34°54'37''.2$ N, $h = 52$ m).

The TV system consists of an image intensifier (Hamamatsu Photonics V1366P) with CCD video camera (JVC GR-S95 at Toyokawa and Panasonic AG400 at Okazaki). The lenses used are a Minolta 135 mm $f/2.0$ at Toyokawa and a Nikon 85 $f/1.4$ at Okazaki; their fields of view have diameters of 10° and 16°, respectively. The limiting magnitude for meteors is estimated to have been between +8 and +10 throughout these observations. The time and date are superimposed on the corner of each video frame every 1/30 of a second. For image processing, video frames are digitized (512 × 512 dots) by a Fujitsu FM-Towns (80386DX computer). Meteor images are measured with the graphics software NEW TRANSFER 1.1. Between 15 and 20 reference stars surrounding the trail are taken from *Sky Catalogue 2000*. The positions of each meteor are reduced and fitted using the general linear constants and taking optical distortion into account. In this system, the position of the meteor is calculated to an accuracy of one minute of arc.

Table 1 – Trajectories and orbits of TV January π-Virginids (eq. 2000.0).

Meteor Id.	15301D	15351D	15357D	16218D	16407D	11337D	22404D
Date (UT)	1994 Jan 14 $18^h01^m46^s$	1994 Jan 14 $18^h51^m10^s$	1994 Jan 14 $18^h57^m04^s$	1994 Jan 15 $17^h18^m49^s$	1994 Jan 15 $19^h07^m18^s$	1992 Jan 10 $18^h37^m18^s$	1993 Jan 21 $19^h04^m30^s$
$\lambda_\odot$	294°.4	294°.5	294°.5	295°.5	295°.5	289°.9	301°.9
α	177°	180°	179°	176°	175°	176°	187°
δ	+09°	+08°	+10°	+08°	+13°	+07°	+08°
V_∞ (km/s)	65	62	64	66	63	68	63
h_{beg} (km)	114	116	107	99	112	112	115
h_{end} (km)	101	101	95	87	97	100	107
cos ZR	0.49	0.45	0.42	0.56	0.38	0.45	0.44
e	0.99	0.86	0.93	1.04	1.01	1.05	0.90
q (AU)	0.37	0.39	0.41	0.37	0.29	0.52	0.42
a (AU)	33.7	2.7	5.7	−10.3	−37.9	−10.3	4.2
i	162°	163°	158°	165°	152°	169°	155°
ω	284°	289°	283°	283°	295°	265°	282°
Ω	294°.4	294°.5	294°.5	295°.4	295°.5	289°.9	301°.9
sin Q	0.32	0.50	0.61	0.26	0.35	0.51	0.53
Magnitude	+6	+5	+7	+4	+5	+5	+6
Frames	7	9	6	7	8	5	5

The trajectories and orbital data determined by calculations using a personal computer with software made by Mr. Ueda are listed in Table 1, where *Date* is the time in UT when the meteor appeared, $\lambda_\odot$ is the solar longitude (eq. 2000.0), α and δ are the coordinates of the corrected radiant (eq. 2000.0), V_∞ is the no-atmosphere velocity (km/s), h_{beg} is the beginning height (km), h_{end} is the ending height (km), $\cos ZR$ is the cosine of the zenith angle of the apparent radiant, e, q, a, i, ω, and Ω are orbital elements (eq. 2000.0), $\sin Q$ is the sine of the angle between the two great circles of the meteor paths as seen from the two stations, *Magnitude* is the approximate TV magnitude, and *Frames* is the number of frames on which the meteor appears at Toyokawa station (30 frames/second).

The orbits of this new stream are well-determined as can be seen in Table 1. Generally, *Coma Berenicids* are comprised of faint meteors whose radiant is at about $\alpha = 185°$ and $\delta = +20°$ [2,3]. The orbital data of the new stream (called January π-Virginids) are different from those of the "traditional" Coma Berenicids (see Table 2). TV surveys during carried out during January since 1989 have revealed many minor showers radiating from near Coma Berenices [4]. These minor showers, such as the January π-Virginids, may have the same origin, and they are all members of the Coma Berenicid Complex.

Table 2 – Radiant and orbital data of Coma Berenicids (eq. 1950.0) and TV January π-Virginids (eq. 2000).

Stream	Radiant		e	q	ω	Ω	i
	α	δ		(AU)			
Coma Berenicids (1950.0)							
Jacchia (1954)	185°7	+20°7	1.08	0.469	270°5	299°8	130°6
McCrosky (1959)	187°	+18°	1.04	0.548	263°1	296°7	136°8
TV Jan π-Virginids (2000.0)							
Suzuki, et al. (1994) (mean of 7 meteors)	179°	+ 9°	0.97	0.40	283°		161°

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Enhanced Ursid Activity in 1993?

communicated by Peter Brown

Peter Brown was informed by Robert Lunsford of unusually strong Ursid activity on the morning of December 22. Lunsford obtained uncorrected counts as high as 26 per hour under skies with limiting magnitudes near 6.5. Another observer from North Dakota, Jay Brausch, also reported raw rates of 24 per hour at virtually the same time, also under good sky conditions—both of these yield ZHRs in the order of magnitude between 50 and 100! The *IMO* is interested in any other observations in the interval 11^h–17^h UT when this possible "outburst" was going on...

The Makings of Meteor Astronomy: Part VI

Martin Beech, University of Western Ontario

The 18th century was a period of great transition in the history of meteor astronomy. For the first time, theory and observation were being brought together, and interesting ideas concerning the origin of meteors were developed.

1. Back to Aristotle

When Edmund Halley initially rejected the idea that fireballs were produced by the ignition of sulfurous vapors, he made great play of the inherent difficulty of having such vapors ascend to the top of the Earth's atmosphere. How was it, he reasoned that the vapors could be raised *so as to surmount the extreme cold and rareness of the air in the upper atmosphere* [1]? Seeing no apparent way around the problem, Halley confidently developed his extraterrestrial hypothesis in which fireballs were produced when matter that had gathered *by some fortuitous concourse of atoms* struck the Earth's atmosphere. The difficulty of getting sulfurous vapors to the top of the Earth's atmosphere was one of the key arguments that Halley leveled against the Aristotelean model for meteor origins in his 1714 paper. Interestingly, however, it seems that, by 1716, Halley had changed his mind on such matters. The first inklings that Halley had become more favorably disposed towards the rising-vapors hypothesis can be found in an article he wrote about the March 1715 auroral display. On March 6, 1715, the whole of Europe was treated to a remarkable auroral outburst. (The event is interesting not just because Halley wrote about it, but because it took place at the end of the Maunder Minimum—a period lasting some 70 years during which it seems that sunspot activity essentially ceased [2]). The paper that Halley presented to the Royal Society was both a review of the event and a discussion of its origin [3].

In his discussion of what processes caused the aurora, Halley initially considered, but then rejected, the Aristotelean idea of rising vapors. His reasons for rejecting the rising-vapors hypothesis were that the phenomena is *always seen to the Northside of the horizon and never to the South*, and because he was worried about how such a vast quantity of vapor could accumulate. It is significant that Halley did not introduce the argument questioning how it was that the vapors might rise to the uppermost reaches of the atmosphere. Halley saw his way around this problem by citing some experimental results which he attributed to the Reverend John Whiteside. Halley noted in particular that *the vapors of gunpowder, when heated in vacuo, ... shine in the dark, and ascend to the top of the receiver though exhausted: the experiment of which I saw very neatly performed by Mr. J. Whiteside, Keeper of Ashmole's Museum in Oxford.*

Experiments in which gunpowder was fired in vacuo were performed before the Royal Society on several occasions in the years around 1700. Indeed, Halley gave several demonstrations himself. In an unpublished paper read on March 2, 1686, and entitled *An experiment of the influence of the air in kindling of phosphorous*, Halley describes one experiment to find *whether the gunpowder in vacuo will be kindled at all.* The most extensive and well-documented series of experiments on gunpowder and "mercurial phosphorous" were those by Francis Hauksbee, who between 1704 and 1707 presented a number of papers to the Royal Society. Halley had been Savilean Professor of Geometry at Oxford for ten years when, in 1714, John Whiteside became keeper of the Ashmolean Museum. Whiteside was instrumental in establishing several new courses in experimental philosophy at the museum's School of Natural History [4]. These courses were embellished with demonstrations of "standard experiments," but unfortunately no detailed accounts of Whiteside's methodology have survived. However, in the pneumatics section of his syllabus, Whiteside does list experiments concerned with *the influence of air on fire and flame—gunpowder fired in vacuo ... Experiments upon different sorts of phosphorus...* It was presumably the demonstration of such experiments that convinced Halley that flammable vapors could gather in the Earth's upper atmosphere, and thereby cause the appearance of bright meteors (and possibly aurora). It is not entirely clear why Halley paid such close attention to Whiteside's experiments, and seemingly ignored those of Hauksbee.

Halley's third and final work on meteoric phenomena appeared in 1719 [5]. This last work was concerned with the observations relating to a *wondrous luminous meteor* seen on March 19, 1718. Gathering the observations (some of which were supplied by John Whiteside at Oxford), Halley calculated that the meteor formed at a height of 64 statue miles and had a velocity of more than 300 miles a minute—*a swiftness wholly incredible*.

Having first sighted the experiments performed at Oxford by Whiteside, Halley explained of the fireball, *... comprehend how the matter of the meteor might have been raised from a large tract of the Earth's surface, and ascended far above the reputed limits of the atmosphere, ... its atoms might in length of time coalesce and run fortuitously together, ..., and gradually contracting themselves into a narrow train compress, might lie like a train of gunpowder in the ether, till catching fire by some internal ferment, ..., the flame would be communicated to its continued parts, and so run on like a train fir'd.* It is clear from his explanation of the origin of the March 19th fireball that Halley has reverted to an Aristotelean rising-vapors hypothesis for the origin of bright meteors.

While Whiteside's experiments clearly influenced Halley's later thinking on meteor origins, he was also concerned that his extraterrestrial-matter hypothesis could not explain the great speeds that fireballs were observed to have (we note that Halley's velocity estimates were a little on the low side, being of order 5 to 10 km/sec). In his 1714 paper, Halley had suggested that the "atoms" which made-up the "meteoric matter" formed in the ether, and then fell towards the Sun under the influence of gravity alone; it was quite impossible, therefore, for such matter to acquire the high velocities that were observed. For this reason, Halley suggested that the fireball *was not a Globe of Fire that ran along, but a successive kindling of new Matter.*

Halley was somewhat vague on how it was that the vapors, having risen to the top of the atmosphere, would coalesce and form long strands of flammable gas. In the main body of his text, Halley used the phrase *run fortuitously together*. He later added a note (presumably at the proof-reading stage) to delete the word "fortuitous." This change to the text would suggest that Halley came to believe that the train formation process was inevitable, although driven by some unknown process.

2. After Halley

In the forty year period that preceded the first of Halley's papers on meteoric phenomena, just three letters were published in the *Philosophical Transactions of the Royal Society* on the subject of fireballs. In the forty year period that followed Halley's 1719 paper, however, a total of fifteen letters were published.

I think it would be incorrect to say that that this five-fold increase in meteor related letters was entirely due to Halley's investigations. Judging from the nature and content of the post-1719 letters, it would appear that more people were simply reporting their observations. Little or no speculation was made concerning the origin of fireballs in these letters, and the observers tended to offer few details of the event other than daily temperature and weather characteristics.

One letter published in 1727, however, rises above its contemporaries for its content and insight [6]. This letter, which was written by George Lynn, addresses an issue that Halley had earlier mooted in his 1719 paper. Namely, Halley had reasoned that two-station observations of fireballs could be used as a means of determining geographic longitude. Lynn notes that rather than relying on the observations of fireballs, which pass only rarely, two station observations could be made of the *common Meteors*, or shooting stars. Lynn argued, *these natural Rockets I have found to be very frequent in every Star-light Night; but especially after a stormy Day, or in a stormy Night*. It is clear from his letter that Lynn is not entirely sure of the heights that should be attributed to shooting stars. He initially suggests a height of *20 or 30 Miles high*, but goes on to say, *It would, however, be worth While, ..., to try whether such common Meteors are discharged, at any considerable Height above the Clouds, and how far, and whether they differ much from one another in their Heights.*

Lynn's letter is interesting because it clearly indicates that at least some people were aware of the fact that shooting stars were common night-time phenomena. The first systematic study to gauge meteor heights, however, was not attempted until 71 years after the publication of Lynn's letter. Likewise, it was to be some 112 years after the publication of Lynn's letter before an attempt was made to derive an observer's longitude from meteor observations [7].

3. A more noble origin

After Halley's investigation of the March 1718 fireball, the next bright meteor to receive a detailed examination was that of November 26, 1758. A summary of the collected observations was presented to the Royal Society by John Pringle [8].

In his analysis, Pringle raised eight objections to Halley's suggestion that meteors consist of *sulfureous vapors arising from the Earth.* He questioned the reliability of the experiments that Halley had quoted, and he questioned how it was that the vapors retained their "volatility" in the cold upper atmosphere, and why it was that the vapors formed long thin lines, rather than coalescing into globules. Pringle also questioned what mechanism was responsible for setting the vapor on fire. In addition to questioning Halley's hypothesis, Pringle also noted that *some have been of the opinion, that these fiery meteors are only a kind of lightning, at greater heights than common.* The lightning idea was dismissed out of hand, however, with the quip *this hypothesis having gained no credit, I need not employ time in refuting it.* We shall return to the lightning model of fireball origins next time. Having weighed the theories and observations carefully, Pringle argued that the best model of meteor origins was that suggested by Halley in his 1714 paper, that is, the extraterrestrial model in which matter formed in the ether through the *fortuitous concourse of atoms.* Pringle continued, however, *surely we are not to consider them* [fireballs] *as indifferent to us, mush less as fortuitous masses, or trains of terrestrial exhalations in the aetherial regions; but rather as bodies of a nobler origin, possibly revolving about some center, formed and regulated by the creator for wise and beneficial purposes, even with regard to our atmosphere; which during their combustion, they may supply with some subtle and salutary matter, or remove from it such parts as begin to be superfluous, or noxious to the inhabitants of the earth...*

Pringle's comments, while clearly bearing religious overtones, are remarkable in the sense that they suggest the possibility that fireballs are not only extraterrestrial masses, but that they may be masses which follow well defined orbits (not necessarily about the Sun). Pringle also introduces the idea that there might be some physical reaction between the gases in the Earth's atmosphere and the meteoric masses.

4. Next time

The idea that meteors might be some form of high atmospheric lightning is a very old one. Towards the close of the 18th century, several detailed models were developed in which meteors and fireballs were identified as electrical discharges. This topic will be the focus of our next instalment.

References

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Fireballs and Meteorites

Fireball

Czech Republic, November 18, 1993, $18^{h}19^{m}00^{s} \pm 5^{s}$ UT

Pavel Spurný, Ondřejov Observatory

On the evening of November 18, 1993, a Northern Taurid fireball of approximately −9 maximum absolute magnitude was photographed by four Czech stations of the European Fireball Network.

A spectacular fireball of −9 peak absolute magnitude belonging to the Northern Taurid stream was photographed in November 18, 1993. The fireball traveled a 72.20-km luminous trajectory in 2.645 seconds and terminated its light at a height of 58.98 km. The following very accurate results are based on the two best records from the stations Ondřejov and Telč. Time of the fireball passage was determined from the combination of the records from Ondřejov fixed and guiding cameras. Two strong and many small flares were registered in the second part of the luminous trajectory of the fireball. The fragmentation into two or three pieces in the last third of the trajectory is clearly visible on records from the Czech southern station Telč. This is one of the best photographically documented Northern Taurid fireballs.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	29.926 ± 0.010	29.23	21.6 ± 1.8
Height (km)	96.37 ± 0.05	67.93	58.98 ± 0.04
Latitude (° N)	49.5857 ± 0.0005	49.534	49.5168 ± 0.0005
Longitude (° E)	15.6029 ± 0.0004	14.906	14.6829 ± 0.0003
Abs. magnitude	− 4.2 ± 0.3	− 9.0 ± 0.3	− 4.2 ± 0.3
Photomet. mass (kg)	0.69	0.38	none
Z R (°)	60.83 ± 0.05		61.43 ± 0.05

Fireball type: II
Ablation coefficient: $(0.0501 \pm 0.0007)\ s^2/km^2$
Member of the Northern Taurid Stream.

Table 2 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	62.53 ± 0.05	64.37 ± 0.06	
δ (°)	+25.63 ± 0.05	+24.09 ± 0.05	
λ (°)			13.83 ± 0.03
β (°)			+01.99 ± 0.04
Initial velocity (km/s)	29.928 ± 0.010	27.496 ± 0.011	37.30 ± 0.02

Table 3 – Orbital data.

Orbit (2000.0)	
a	2.198 ± 0.008 AU
e	0.8240 ± 0.0004
q	0.3868 ± 0.0007 AU
Q	4.008 ± 0.016 AU
ω	290°.31 ± 0°.11
Ω	236°.5343 ± 0°.0003
i	2°.93 ± 0°.05

Fireball

Germany, February 15, 1994, $23^h06^m23^s \pm 5^s$ UT

Pavel Spurný, Ondřejov Observatory

On the night of February 15-16, 1994, a fireball of approximately −9 maximum absolute magnitude was photographed by four Czech stations of the European Fireball Network.

A slow-moving fireball of −9 maximum absolute magnitude was photographed by four Czech stations of the European Fireball Network on the night of February 15-16, 1994. The fireball traveled 80.20-km during its luminous trajectory in 4.46 seconds and terminated its light at a height of 34.04 km. The following very accurate results are based upon all available records. Time of the fireball passage was determined from the combination of the records from Ondřejov's fixed and guided cameras. Very precise dynamical data permitted use of the gross fragmentation model [1]. The fragmentation at two points on the fireball trajectory was detected and the resulting dynamical solution is much more precise than classical solutions using the single body model.

Table 1 – Trajectory data.

	Beginning	Maximum light	Terminal
Velocity (km/s)	23.890 ± 0.008	21.67	4.0 ± 0.9
Height (km)	81.64 ± 0.06	49.50	34.04 ± 0.06
Latitude (° N)	51.3766 ± 0.0004	51.014	50.8371 ± 0.0005
Longitude (° E)	14.1013 ± 0.0010	13.888	13.7854 ± 0.0011
Abs. magnitude	− 4.4 ± 0.5	− 8.7 ± 1.1	− 3.6 ± 0.5
Photomet. mass (kg)	2.75	1.7	< 0.05
Z R (°)	53.308 ± 0.013		53.852 ± 0.013

Fireball type: Ib
Ablation coefficient: $(0.0130 \pm 0.0002)\ s^2/km^2$
Possible member of the δ-Draconid Meteor Stream.

Table 2 – Radiant data.

Radiant (2000.0)	Observed	Geocentric	Heliocentric
α (°)	273.96 ± 0.03	280.81 ± 0.03	
δ (°)	+ 69.41 ± 0.02	+ 67.01 ± 0.02	
λ (°)			54.441 ± 0.009
β (°)			+33.812 ± 0.012
Initial velocity (km/s)	23.849 ± 0.008	21.002 ± 0.010	37.636 ± 0.007

Table 3 – Orbital data.

Orbit (2000.0)	
a	2.338 ± 0.003 AU
e	0.5783 ± 0.0006
q	0.9859 ± 0.0001 AU
Q	3.690 ± 0.007 AU
ω	173°90 ± 0°02
Ω	327°1296 ± 0°0001
i	33°841 ± 0°012

[1] Ceplecha, et al., "Atmospheric fragmentation of meteoroids", *Astron. Astrophys.* 279, 1993, pp. 615–626.

Large Bolide over Western Pacific on February 1, 1994

compiled by Marc Gyssens

A super-fireball was both visually observed and detected by a US Government satellite system.

Recently, the US Air Force released the following information:

At 22^h38^m UT on February 1, 1994, a very large fireball was observed over the Western Pacific Ocean (2°7 N, 164°1 E). Observations include infrared tracks recorded by two satellites, accompanied by long-persistence trails, plus visible-light flash responses from six satellites in view of the region. In addition, a report of visual sighting by two local fishermen, some 12 km southeast of Kosrae: According to the report, the fireball traveled from northwest to southeast of Kosrae, and remained visible for three to four seconds. The tailing smoke remained for about one hour. The flame was reddish and bluish in color and very bright. They heard no explosion nor did they notice any unusual bright flashes beyond the horizon. From satellite visible light sensor data, it has been possible to estimate the peak flash intensity and radiated energy of the event at 2.5×10^{13} Watts and 1.4×10^{13} Joules, respectively, using a conservative model of 6000 K black-body radiation. That peak intensity corresponds to a visual magnitude of -25. This event surpasses in intensity the brightest fireball previously recorded by satellite sensors, an April 16, 1988, event (also in the western Pacific) whose visual magnitude was -24.3.

A preliminary interpretation of the phenomenon was made by David Morrison and Kevin Zahnle of the Ames Research Center, based on data from Los Alamos (most of which mentioned in the above release) and additional information provided by Doug ReVelle. Here we publish a summary with the kind permission of Dr. Morrison.

The Los Alamos people compared the final flash with a nuclear airburst (assumed 6000 K fireball) and concluded that the event was energetically equivalent to an 11 Ktn airburst. Since 11 Ktn is 4.6×10^{13} Joules, this implies a luminous efficiency of 30%. However, typical estimates for fireballs are 1% or less. Thus the range of yields can only be constrained to the very broad range of about 10 Ktn up to 1 MTn. If the yield was, say, 100 KTn and the entry velocity 15 km/s (i.e., asteroidal and not cometary), the mass was about 4000 tons and the diameter (for a rocky object with density near 2.5 g/cm^3) was about 15 m. If the entry speed was 20 km/s, the mass would have been 1000 tons and the diameter 9 m. The range of fireball efficiencies permits the yield to have been as high as 1 MTn, for a mass of 10 000 to 40 000 tons and a diameter of 20 to 30 m. The models developed by Chyba and Zahnle to study Tunguska, the small Spacewatch objects, and the cratering flux at Venus suggest that an object with the characteristics indicated will indeed explode near 20 km altitude. For the nominal entry angle and velocity, the models suggest that the object was probably a weak stone (i.e., carbonaceous). Basically the February fireball can be thought of as a smaller version of Tunguska which, because of its smaller size, exploded at 20 km rather than 8 km altitude. According to the standard Shoemaker flux curves, the average frequency of such impacts is between 5 and 50 years.

Revelle, on the other hand, suggests that the object was cometary, either a Type II or a Type III fireball, with probable density of 0.2 g/cm^3 and diameter of 16 m. We think this is an unreasonably low density. We have modeled the entry of such an underdense object and find it will penetrate to 20 km only if it is very strong, like an iron or strong stony meteorite. If it has the physical strength of a carbonaceous meteorite it explodes above 30 km, and much higher yet for probable cometary strengths that might be associated with the assumed low density. So, cometary strengths and densities are difficult to reconcile with the observations. Although there is a rather basic disagreement here in the interpretation of the data, perhaps we can all agree at least that the February fireball was larger than the Hiroshima bomb (likely 10 times larger) and corresponds to a roughly decadal impact event.

With some concern, Morrison and Zahnle noted that the President was apparently wakened in the night because it was suspected that this might have been a hostile nuclear event!

Investigation of Possible Meteorite Fragments in a Tree Trunk Disk from the Tunguska Meteorite Site

communicated by Toshio Kamimura

The members of the Earth Science Club, Arai High School, Niigata Prefecture, Japan, studied a tree trunk disk from a Schrenk Spruce, approximately 130 years old, that had been influenced by the Tunguska event. We found 101 microscopic fragments of possible meteoric origin in this sample. We believe these particles to have come from the Tunguska Meteorite.

1. Introduction

The members of the *Earth Science Club* were asked to try to find spherulite material in a tree trunk disk, collected in November 1992 from a tree located near the point of the Tunguska impact. The request was made by Toshio Kamimura who had participated in the *International Tunguska Expedition* in August of that year.

The members of the *Earth Science Club* had been speculating that there is a relationship between fallen meteorites and cosmic particles (meteoric dust). Therefore, they decided to participate in research concerning this material.

2. Method of investigation

The material was investigated according to the following procedure:

1. One quarter piece was cut from the tree trunk disk.
2. The growth rings in the quarter piece are divided into ten groups as follows: groups 1 and 9 include 30 years of growth rings each. Groups 2–8 include 10 years of growth rings each. Group 10 is the bark of the tree.
3. Each group was burned to ash.
4. The ash lumps were broken up, using a mortar and pestle, but not ground into dust.
5. A magnet was used to collect any magnetic particles in the ash.
6. The presence of meteoric fragments among the magnetic ash particles was determined with the use of a binocular microscope.

3. Results of the investigation

The material the members of the *Earth Science Club* were asked to investigate consisted of a tree trunk disk from an approximately 130 years old Schrenk Spruce, with a diameter of 23.9 cm and a weight of 225 g.

The result of the experiments are summarized in Table 1. During this investigation, 101 microscopic fragments of meteoric origin were found. Their sizes varied from a maximum of 35 μm to a minimum of 8 μm. There is no certainty, however, that all of the detected fragments are connected to the Tunguska Meteorite. If they were from the Tunguska Meteorite how did they come to be embedded in the core of the tree? And why were they found in different growth rings? Five possible explanations have been proposed to explain this:

1. The fragments fell in large numbers at the same time as the meteorite and entered the tree through its roots.
2. When the meteorite fell, the fragments sank into the trunk of the tree from the force of the explosion.
3. When the meteorite fell, the fragments attached to the sap on the trunk or entered through cracks in the trunk.
4. The fragments which entered the tree were moved around inside the tree by cell division as the growth rings enlarged.

Table 1 – Cosmic particles in the tree trunk disk from Tunguska. The investigators were Kyoko Mizuguchi (KM) and Fumiko Ohtaki (FO).

Sample	Age of tree ring	Weight of material (g)	Investigator	Number of particles
1	1868–1894		KM and FO	63
2	1895–1904		KM and FO	5
3	1905–1914		KM and FO	4
4	1915–1924		FO	2
5	1925–1934	3.37	FO	3
6	1935–1944	3.35	KM	2
7	1945–1954	2.12	KM	2
8	1955–1964	2.75	KM	1
9	1965–1991	1.93	FO	18
10	(bark)	1.96	FO	1
Total		15.48		101

5. There might have been many meteorites which fell in addition to the Tunguska meteorite with fragments included in the tree trunk.

The members of the *Earth Science Club* plan to undertake further study of this to come to a more definite conclusion, but we feel that we need to study samples from other sites where meteorites have fallen, so that we have more information to draw conclusions from.

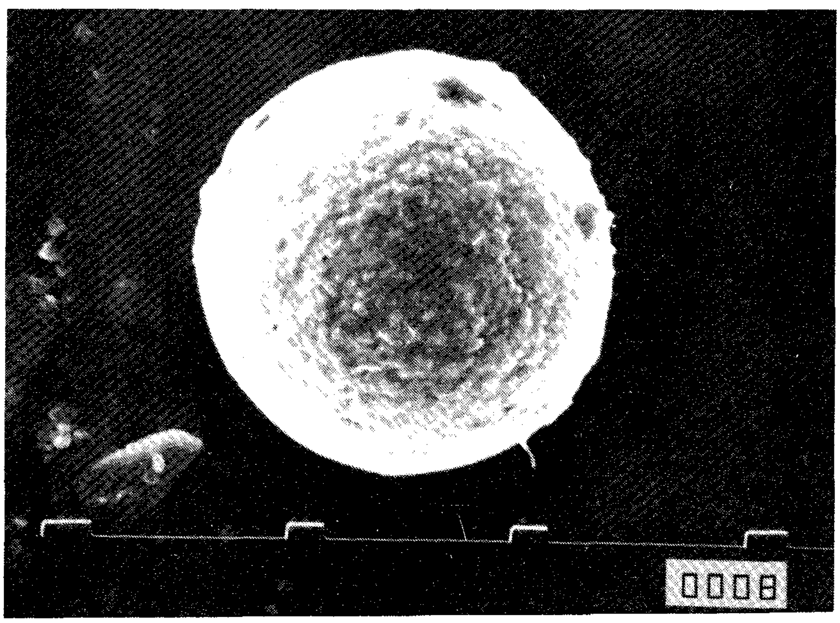


Figure 1 – Cosmic dust particle, 3500× enlarged.

Observational Results

The 1993 Perseids and the Meteoroid Dust Cloud

Casper ter Kuile, Marco Langbroek, and Jacob Kuiper

An overview is given of observations of the Perseids 1993 in the Provence by members of the *Dutch Meteor Society (DMS)*. We present preliminary results of visual and photographic observations. A likely observation of the Perseid meteoroid cloud in space is discussed.

1. Introduction

In 1992, a very successful "crash" campaign was organized by members of the *Dutch Meteor Society (DMS)* to a region near Basel/Mulhouse in order to observe a possible Perseid outburst [1]. Indeed, observers Marco Langbroek, Peter Jenniskens, Carl Johannink, Romke Schievink, and Casper ter Kuile did observe the last 20 minutes of an outburst, albeit in deep twilight.

The excitement of that event led us to organize a more extended expedition in August 1993 [2]. In order to escape the usually unpredictable weather conditions in the Netherlands, a multi-station network was set up in the Provence in the South of France, the nearest place with good prospects for clear weather. The aim of our expedition was to obtain a good activity profile from visual and radio observations and high-precision orbital elements of multi-station photographed meteors associated with the outburst.

This article will summarize the preparations and results of our campaign [3,4]. As a special topic, we present a detailed description of the Perseid meteoroid cloud which has actually been observed by two independent observing groups who were located at a great distance from each other.

2. Preparations

A series of newsletters informed our members of progress in the organization [2]. On Saturday, June 12, 1993, *DMS* organized a preparatory meeting at Harderwijk, the Netherlands, which was attended by 25 meteor observers. Special guests were the Belgian *VVS Meteor Section* representative Peter Aneca and the *IMO* representative Paul Roggemans. We evaluated the logistic problems associated with an expedition, the meteorological aspects of the chosen site, and the necessary changes to the observing techniques in case of high meteor rates.

Figure 1 – Group photograph at the meeting in Harderwijk.

Figure 2 – Meteosat-4, August 12, 1993, 6^h30^m UTC, Visible. © ESA/EUMETSAT/KNMI.

Most visual observers were going to work with tape-recorders, which are often equipped with "time-indexed recording." During the quiet part of the night, we were to record each meteor's brightness, shower classification, distance from center of vision (DCV), angular velocity, and sky location. As activity rose, information was to be restricted to brightness, if possible DCV, and a note on classification in case the meteor was a non-Perseid. One of us, Marco Langbroek, who preferred to use pencil and paper for recording, decided to only count during five-minute intervals with the aid of his Casio watch equipped with an audio-signal countdown mode; this meant no magnitude information was obtained.

In order to modify our photographic techniques to suit high meteor rates, new equipment was built that allowed for short exposure times and a minimum of dead-time between exposures [5]. Short exposure times greatly ease the correct identification of meteors on negatives. An exposure time of 10 minutes was decided upon as a good balance between available film length and short exposure time. A fully automatic camera battery was needed. Therefore, we used Canon AV-1 cameras equipped with winders which are controlled by a Canon T-70 with a command back 70. The command back is programmed with a timing accuracy of 1 second. For very high rates, reprogramming of the exposure times was possible. The accuracy of the calculated orbital elements highly depends on the accuracy of the time measurements and the frequency of the rotating shutters. Precise timing was acquired by means of a DCF time signal from Frankfurt. Much effort was spent in constructing high-accuracy neatly balanced quartz-controlled rotating shutters. All these efforts enabled us to achieve accuracies of 0.05 km/s or better in meteoroid speed determinations.

Two new automatic camera batteries were built by Koen Miskotte and Casper ter Kuile for the station at Rognes, France. Jaap van 't Leven constructed a similar system for Tourves, and Romke Schievink and Jerôme de Jong van Lier constructed a system for Lardiers. In addition, Robert Haas completed an automated 6×6 all-sky camera for Rognes. Klaas Jobse prepared video image intensifier (IPCS) systems that were set up in Puimichel, Lardiers, and Tourves.

On August 10, 1993, a second meeting was organized by the *IMO* at Puimichel. An important topic to be discussed during this meeting was the weather prediction provided by Jacob Kuiper. The weather forecast was very favorable, and indeed the Meteosat-4 picture in the early morning of August 12 showed an almost cloudless Southern France (Figure 2).

3. Multi-station network

Late in 1992, members of the *DMS* wanting to participate in the project formed four observing groups. Each group hired a house from the "France Gîte" organization. These gîtes were chosen to be located about 50 to 70 kilometers apart in order to have optimum geometrical conditions for multistation photography and video observations (see Figure 3).

Marc de Lignie, Klaas Jobse, and Michiel van Vliet settled near Puimichel, where both visual, photographic, and video observations were carried out. A second group, including Jaap van 't Leven, Peter van der Heiden, Frank Kooiman, and Cor Meulmeester, settled between Tourves and Brignole. They observed visually, photographically, by video, and by radio. Carl Johannink, Andre Kluitenberg, Romke Schievink, Jerôme de Jong van Lier, and Ralf Mulder of the *"Werkgroep voor Sterrenkunde"* of Denekamp and some French observers settled in Lardiers. The Lardiers team observed visually, photographically and by video. *DMS* members Marco Langbroek, Koen Miskotte, Robert Haas, and Casper ter Kuile chose Rognes as their observing station. The members of the Rognes team observed visually using time-index recorders, with the exception of Marco Langbroek who used a five-minute count system. In total, 24 fully automated cameras were used for photographic observations.

Several other groups of meteor observers were active in the Provence during the Perseid campaign. In Puimichel, *IMO* members Paul Roggemans, Peter Brown, Martin Beech and Yasuo Yabu, and 35 young observers of the *Dutch Astronomical Association (NVWS)* were present. Puimichel served as an organizational center, and observers could obtain the latest weather information provided by Jacob Kuiper of the *Royal Dutch Meteorological Institute (KNMI)*.

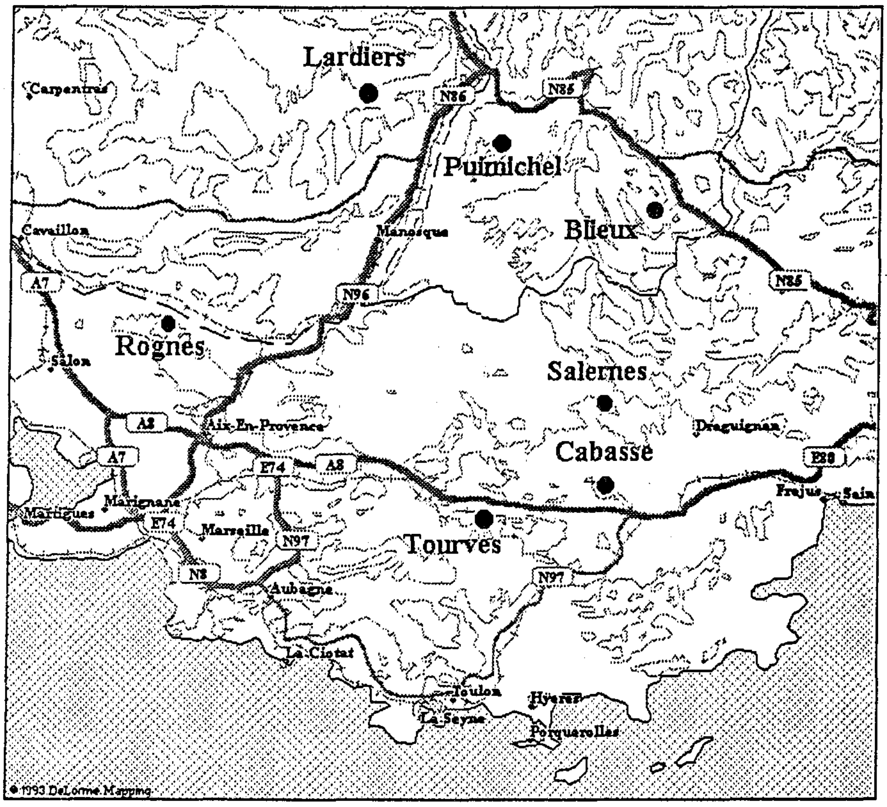


Figure 3 – The observing sites in the Provence.

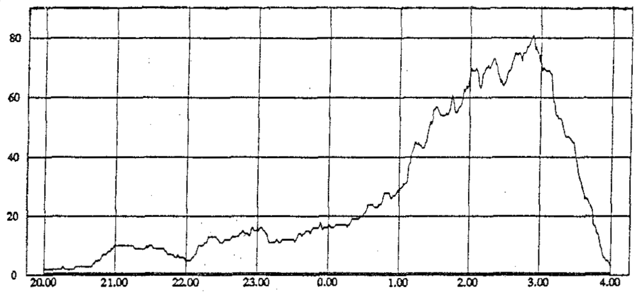
Near Blieux (Castellane), a group of the Belgian *VVS*, lead by Peter Aneca watched for Perseids [6]. Some 30 observers of the *International Astronomical Youth Camp*, among them Erwin van Ballegoy, observed the Perseids near Coucouron (Ardeche). Joe Rao observed from a cruise ship in the Mediterranean Sea [7]. Two observing groups from the *NVWS Meteor Section*, including Felix Bettonvil, Urijan Poerink, Ben Apeldoorn, Niek de Kort, Siem van Leverink, and Serge ter Hall [8], settled in Salernes and Cabasse, about 18 km apart.

Many Dutch observers stayed home and had to face bad weather conditions. Jacob Kuiper, however, tried to escape by traveling to the Vosges Mountains, specifically the Pointe d'Honneck near Colmar in Northern France. He was joined by a group of observers, including Michiel Severin, Edward Hamers, Mark Neits, and Jan Tromp [9]. In addition, a small multi-station project was set up by Peter Jenniskens and Mike Wilson in Los Banos and Livermore in California.

4. Results

Fortunately, August 11-12, 1993, was a fine, clear night with very good conditions, slightly affected by moonlight late in the night. The sky was monitored from the moment of sunset. The first set of bright Perseids appeared around 22^h30^m UT. Everybody thought this was the beginning of the so hoped-for Perseid outburst, but rates declined again, and at 0^h45^m UT the observers at Rognes were in despair about what was going on above. To our surprise—and satisfaction—hourly rates suddenly rose again after 1^h15^m UT. Maximal hourly rates were reached at about 3^h00^m UT shortly before twilight started interfering.

Visual observations were conducted with sky limiting magnitudes reaching +6.9 in the early part of the night, falling to +6.3 after moonrise. From the start of serious observations around 19^h45^m UT until 22^h30^m UT, Perseid activity was normal with a ZHR around 60 and an r-value of 2.5. After 22^h30^m UT, the r-value suddenly dropped to about 1.9, and activity rose to a peak ZHR of about 140 around 0^h15^m UT. This first phase of enhanced activity was followed by a quick decline in activity to almost normal ZHR-values of 70 around 0^h45^m UT. Most notably, the observed r-value fell to almost normal during this period. After this decline, which left observers quite disappointed, activity dramatically rose again after 1^h15^m UT. The r-value again dropped to 1.7–2.1. Around 2^h45^m UT the ZHR value reached about 300. After this time, corrected rates become uncertain because of interfering twilight [10]. Around 3^h15^m UT, most observers registered 25 or more Perseids per five-minute interval. The observations in the Provence ended around 3^h40^m UT. In Los Banos, meteor rates were found to be back to normal by 8^h00^m UT.



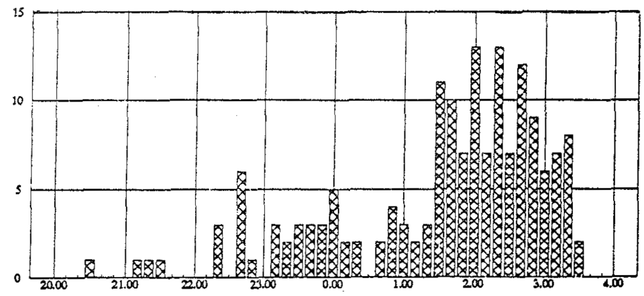


Figure 4 – Hourly rates of bright visual meteors *(left)* and photographed meteors *(right)* during the night of August 11-12. All times are in UT.

Figure 4 *(left)* shows the rate of visually recorded meteors of magnitude 0 and brighter. For these meteors, we recorded time, location, magnitude, and, if relevant, trails and colors. The graph is calculated by means of a 1-hour moving average with increments of 1 minute. Interestingly, the graph does not indicate a peak around 22^h30^m UT nor does it show a clear dip around 0^h45^m UT. Marco Langbroek has suggested that the visually observed decrease in hourly rates around 0^h45^m UT might have been due to a decline in the number of meteors between magnitudes 0 and +2. Such a scenario would explain the difference between visual and photographic results as shown in Figure 4 *(right)*, and still account for the observed r-value differences. Evaluation of the visual results must confirm or reject this hypothesis.

All photographic equipment worked perfectly: 300 meteors had been photographed in Rognes, about 200 of which were obtained on the night of August 11-12, most of these between 1^h30^m and 3^h30^m UT. We expect the total number of multi-station photographed meteors to be near 200, most of them recorded from three or even four stations. Between 1^h30^m and 3^h30^m UT, the negatives show 1, 2, or 3 meteors which are easy to match with the visible observations.

Figure 5 – Perseid photographed by the Rognes team on August 13, $2^h13^m17^s$ UT.

Similarly successful were the video observations. A bright κ-Cygnid fireball was captured by Romke Schievink at Lardiers (August 11-12, $0^h34^m53^s$ UT) and photographically recorded at other stations. During the same night, some confusion as to viewing direction caused many meteors not to be filmed from multiple stations. The problem was corrected the subsequent night, and many multi-station results of annual Perseids were obtained.

5. The Perseid cloud

A highly interesting observation was obtained from the Provence and the Vosges Mountains. Two observing teams at totally different locations observed a diffuse cloud before the peak of the outburst. This cloud may have been caused by sunlight scattered by the dust along the trail of P/Swift-Tuttle. In view of its potential importance, we describe the observations in as much detail as possible. We also try to demonstrate that the cloud could not have as its source any phenomena in the Earth's atmosphere.

In [11,12], Joe Rao indicated the possibility of visually observing the Perseid meteoroid dust cloud. Subsequently, Michiel van Vliet made some computations to find out whether the dust cloud could become visible to the naked eye [2]. His conclusions were quite pessimistic, but nevertheless we watched for the possible occurrence of the phenomenon during the maximum night. Rao had calculated the position of the cloud to be 10° south of Algol. At the time of observation, we were unaware that Duncan Steel had shown the calculated position by Rao to be wrong [13]. The predicted location according to Steel was at the true radiant, which is near Polaris ($\alpha = 33.^\circ5$, $\delta = +84.^\circ7$, eq. 2000.0). Kessler and Zook recommended monitoring the arc between the true and apparent radiant. They also observed that any glow from a dust cloud which would collide with the Earth would become visible at the apparent radiant! [13]

At Rognes, around 0^h39^m UT, observer Robert Haas was the first to notice some kind of cloud near Algol. All of us could clearly see something resembling a streak of cirrus cloud, but surely it was not cirrus! As recorded by Marco Langbroek around 0^h45^m UT and confirmed by all observers [2], it roughly extended from $\alpha = 64°$ and $\delta = +43°$ to $\alpha = 40°$ and $\delta = +36°$ and was centered at $\alpha = 52°$ and $\delta = +40°$ (Figure 6). Although there is some uncertainty as to the extremities of the cloud, its dimensions were at least 2° by 5°. This position was recorded by Marco Langbroek around 0^h45^m UT and confirmed by all observers [2].

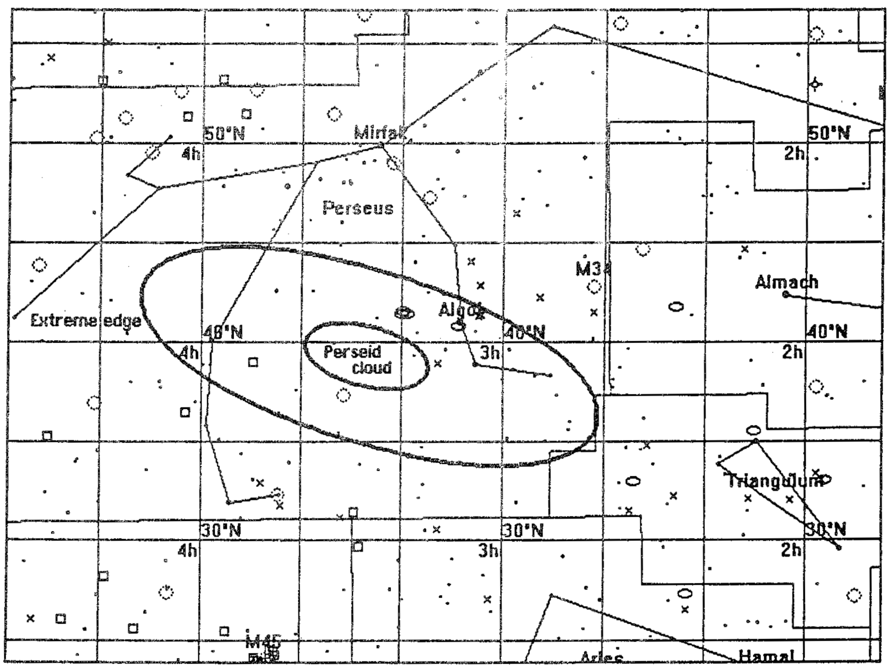


Figure 6 – Position of the cloud observed from Rognes

The cloud was transparent and had a silvery glow resembling that of noctilucent clouds or weak aurorae. The cloud remained stationary with respect to the background stars, unlike the real cirrus which appeared later that night. During the observation, the cloud broadened and became fainter: with an initial magnitude of about +4.5, its brightness at first was comparable to that of the Milky Way in Perseus. The cloud was observed for some 10–15 minutes. About half an hour after the cloud disappeared, Perseid rates began to increase rapidly.

A very similar observation has been made by Jacob Kuiper at the Vosges Mountains near Colmar, Northern France, about 500 km north of Rognes [9]. As a meteorologist, Jacob has much experience with cloud types and he is quite convinced that the phenomenon he observed could not have been a cirrus cloud! Also, Jacob fully agrees with the description of the cloud as seen for Rognes, and he too saw it due east of Algol. Assuming that both observations refer to the same phenomenon, it must be concluded that the phenomenon occurred outside the Earth's atmosphere. Therefore, we are quite sure that we have observed the meteoroid dust cloud in space. To further substantiate this hypothesis, we examined the various atmospheric phenomena that might have caused such a cloud:

1. *Cirrus clouds.* In Colmar, Jacob Kuiper noticed that during 15–30 minutes the glow did not move with respect to the background stars. At that time, westerly winds were blowing with speeds of 60–100 km/h at a height of 7 to 10 km. During that period, a cirrus cloud would have traveled quite a distance in the sky. Later that night, we indeed saw some fast-moving cirrus clouds. Also, the glow was too transparent for a real cirrus cloud.
2. *Noctilucent clouds.* This type of "cloud" consists of meteoritic dust, covered with a very thin layer of water-ice. In the months June, July, and August, these clouds can occasionally be observed 1 to 1.5 hours after sunset or before sunrise north of 50° N. The glow, however, was seen well into the night, south of 50° N.
3. *Aurora.* Aurorae are generally observed at high northern or southern latitudes; when the activity of the sun is very high, they can also be witnessed at lower latitudes. Explaining the glow as an auroral phenomenon poses a parallax problem: a phenomenon at a height of about 100 km cannot be seen in the same direction from two positions 500 km apart. To be absolutely sure the glow could not have been aurora, Jacob Kuiper obtained information on the activity of the ionosphere that particular night from the Head of the Geophysics Department of the Royal Meteorological Institute in Belgium. The data supplied show neither extreme activity of the sun and nor a big disruption of the geo-magnetic field of the Earth; hence we may exclude an aurora as the cause of the cloud.

The parallax argument also excludes other explanations, such as reflection of big town lights on high clouds.

We would like to point out that the observed location of the dust cloud is definitely *not* the same as the (wrong) position indicated by Rao. People may have doubts about our observations, because "our" cloud appeared at another location than it theoretically should have been according to *IAUC 5840*. We would like to point out, however, that the position stated in *IAUC 5840* is given for *a strong concentration of material exactly such that it will collide with the Earth*, and the absence of a meteor storm strongly suggests that the concentration was *not* on an Earth-colliding course! (See also [14,15].) Also, "our" cloud, within the accuracy of the observation, *did* occur on the arc joining true radiant, apparent radiant and anti-radiant.

Assuming we did observe a Perseid dust cloud, a number of questions still remain: At what distance did the Earth and the meteoroid cloud pass each other? What are the dimensions of the dust cloud? Did we observe only a dense part of a filament or the main stream of the Perseid dust cloud? The outburst which happened about 3 hours later was probably caused by the passage of the Earth through a different dust filament. Hopefully, professional astronomers can cast some light on this complicated but very intriguing matter!

Interestingly, a possible photograph of the cloud was presented by Ben Apeldoorn (*NVWS Meteor Section*) after we brought our observation to his attention [8]. However, his photographs were made two to three hours after our sighting and the linear features on it are very different from the phenomenon we observed. In our opinion, these features may have been caused by internal reflections of moonlight in the complex lens system of his fish-eye lens. The only feature which seems not to have been caused by reflected moonlight, bears close resemblance to the isolated cirrus clouds we photographed at Rognes around the same time, and can be seen to be evidently moving across the sky on the series of photographs.

The observers at Rognes and Jacob Kuiper welcome any observation that could confirm our observations, in particular (professional) photographs and CCD registrations. We strongly call for observers to watch for the phenomenon during the 1994 Perseid return!

Acknowledgments

We would like to thank all observers who participated in the 1993 Perseid Campaign and shared this almost "religious" moment with us. We appreciate the logistic support supplied by Paul Roggemans during our stay in Southern France. We also thank Peter Aneca and Erwin van Ballegoy for their cooperation. We also had useful discussions before and after the campaign with Carl Johannink, Michiel van Vliet, Koen Miskotte, Robert Haas, Marc de Lignie, and Hans Betlem. Special thanks go to Peter Jenniskens who spent his precious time to read the manuscript and provide us with many useful suggestions to improve our paper.

Finally, Casper ter Kuile thanks Marco Langbroek for his radical editing of the first draft of this paper, and Marco Langbroek thanks Casper ter Kuile for having spent his Christmas holidays to correct his radical editing...

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Comments by the Editor-in-Chief

The observations described above are indeed quite remarkable and intriguing. As Editor-in-Chief, however, it is my duty to caution the reader against hasty conclusions. Therefore I found it appropriate to publish the following comment by Jürgen Rendtel. I also want to point out that the author's arguments stand or fall with the assumption that both observations indeed refer to the same phenomenon. Although they give some strong arguments to sustain this assumption, the possibility that the two observations are coincidental remains, and in that case many explanations are possible.

Comments by Jürgen Rendtel

In this paper, the authors describe a cloud-like phenomenon, observed from two locations at a substantial distance from each other. Several terrestrial explanations are investigated and are rightfully dismissed. Therefore, the authors conclude that they might have observed the glow of the Perseid meteoroid cloud. Although I cannot offer another explanation here, I would like to stress a few facts which should be kept in mind.

The observation took place when the Moon already was above the horizon. I know of other attempts from northern hemisphere observers to see the glow of the Perseids meteoroid cloud, but they found the moonlight too disturbing. Also, there are no indications for a comparable glow near the anti-radiant from the southern hemisphere (without interference from the Moon) after the phenomenon was seen here.

If we interpret the observation as the Perseid glow, which did not occur at the predicted position, we could assume that the Earth missed a dense particle cloud. However, the structure must have been very narrow spatially and perhaps of another mass distribution. The observed activity reached its peak more than 3 hours later, and the global analyses did not show a variation in the population index r during the ascending activity. Even at the moment that the highest rates occurred on the morning of August 12 (ZHR $\approx$ 350), the number density of particles with a mass of at least 1 mg was lower than that of an average Geminid maximum (see Table 1). Since glow observations of the regular Geminid maximum are not known, we should expect that a much denser particle cloud is necessary to cause such a phenomenon. For comparison, the figures for the Leonid storm are added.

Table 1 – Number densities of particles with a mass of at least 1 mg per 10^9 km^3 ($\rho_{1\ \mathrm{mg}}$) of the Perseids and the Geminids for different conditions. The last line gives the Perseid ZHR to be expected for a number density comparable to the Leonid storm. Note that all figures are rough estimates only.

Shower	r	ZHR	$\rho_{1\ \mathrm{mg}}$	Comment
Perseids	1.8	350	3	Observed 1993 peak at $\lambda_\odot = 139\overset{\circ}{.}535$
	2.5	350	5	Observed 1993 peak, with a higher r
	2.5	700	10	Twice the ZHR, with a higher r
	2.5	1400	20	Like a storm, with a higher r
Geminids	2.2	120	20	Average Geminid maximum
Leonids	2.5	240000	140	Leonid storm
Perseids	2.5	10000	130	Expected Perseid ZHR for a Leonid-storm-like number density

Even if we do not have an explanation of the observation at hand, the interpretation needs much care. I suggest that observers should prepare suitable photographic and LLLTV equipment for the 1994 Perseids to obtain reference data which can be used also for other occasions.

The 1992 and 1993 Perseids from Hungary

Ákos Keresztúri and István Tepliczky

A summary is given of Hungarian Perseid observations in 1992 and 1993.

Hungarian amateurs were able to observe a Perseid outburst in 1992. The 1992 outburst occurred during evening twilight on August 11. It was observed by our main observing group from Csajág, near Lake Balaton. The sky was still blue and only the brightest stars were visible, as well as the rising Full Moon. The limiting magnitude was between +2 and +3. The radiant was only 10° above the horizon, so nobody expected any great activity.

We had just prepared our observing sites when a meteor appeared. Within a minute, we saw several meteors, and an amazing meteor display started. The low position of the radiant resulted in very long Perseids, most of them with trains. We saw 3–6 Perseids per minute. It was very hard to organize "serious" observing, since our observers were very excited by the sudden celestial firework. Our observing session had started at 19^h00^m UT, but by that time the activity had already declined. Unfortunately, the results of the observing session are uncertain, because the limiting magnitude varied rapidly between 3.5 and 4.5.

The *Hungarian Astronomical Association* organized an extended observing campaign on August 11-12, 1993. We brought the event to the attention of the public, and most newspapers published predictions for a great meteor storm, and all major radio and TV channels announced the phenomenon. It is estimated, that about 50 000 people spent the night under the clear sky.

Our observing stations covered the whole country: 154 observers sent reports from 44 sites. The activity began to rise around 23^h00^m UT. We observed three short-lived peaks at 23^h30^m, 1^h00^m and 1^h45^m UT, respectively.

We observed many groups of Perseid meteors and even twin shower members. Almost all Perseids brighter than magnitude +3 showed trains. We noticed another interesting fact: most Perseids had a continuous train, but some of them showed a drop about halfway along their path.

JASMS Results on the 1993 Perseids

Alastair McBeath

A summary of UK and overseas results reported to the *JASMS* in August 1993 is presented.

1. Introduction

During August 1993, 29 individuals and members of nine groups (totaling well over sixty observers in all) provided data to the *JASMS*, making this one of our most impressive summer observing campaigns of recent years. The combined efforts of those people comprised 219.83 hours of visual watching, with 5011 meteors (3457 Perseids) reported. Four observers also put in 49.67 photographic hours, with 73 meteor trails successfully recorded, and one radio observer submitted a short report for the night of August 11-12, although unfortunately before the main peak occurred that night. The list of contributing observers follows:

> Peter Ball, Tony Beale et al., Charlotte Bland, Neil Bone, Marcus Buffrey, Chris Durman, Dave Gavine et al., Shelagh Godwin et al., David Graham, Guernsey AS, Carl Harris et al., Alan Heath et al., Terry Holmes, David Jenkins, Simon Jenner, Richard Livingstone, James Lunny, Lee MacDonald, Julie Maginn, Tony Markham, Alastair McBeath, Heather McBeath, Peter McBeath, Tom McEwan et al., T. Oldroyd, Graham Pointer, Edward Polehampton et al., Ian Rigney, Paul Roggemans, Dave Scanlan et al., George Spalding, Paul Sutherland, Chris Taylor, Steve Tidey, Roy Watson, and Mike White.

2. Perseid activity summary

UK watches after Full Moon became possible from August 5-6, but only after August 9-10 did meteor and hours' tallies really start to rise. August 10-11 saw an increase in the number of observers in action, but clouds held watch lengths down generally, though a couple of spectacular fireballs were recorded at around 20^h and 22^h05^m UT, both rivaling the Full Moon.

The critical night, of course, was August 11-12, and most sites in Southern Britain were unfortunately cloudy throughout, but some observers north of this region did get some clearer spells, and saw excellent Perseid activity. No UK visual watch was over 4 hours in length, and many people ended up trying several watches during the night. Lucky observers, mostly those who had traveled to Southern France, recorded high rates, as already reported elsewhere in *WGN*. In all, the night yielded 1573 meteors (1379 Perseids) in 32.5 hours. Perseid ZHRs were clearly increasing all night, with the highest UK ZHR about 200+ towards the end of the night. Many more bright and trained Perseids were reported than normal.

August 12-13 was a far better night for British observers, and totals were still higher—91 hours and 2400 meteors, including 1663 Perseids. Six groups plus 25 individuals were out observing, resulting in numerous fine efforts. Longest watches were of 5.5 hours duration, with meteor totals ranging between 170 to 280 (most of these Perseids) in this amount of time. Observers who were able to put in four or five hours of watching were usually treated to around or over 100 meteors for the night. Although Perseid rates were naturally lower than on August 11-12, falling from UK ZHRs of roughly 70 to 50 overnight, and fewer bright meteors were apparent, 26 fireballs were recorded, two of these from several sites, at 23^h51^m and 2^h09^m UT.

August 13 to 15 were disappointing, but undoubtedly many observers were also recovering from their efforts on the preceding couple of nights. The last night on which substantial totals were reported was August 16-17, when 13 observers watched the, by then, failing Perseid rates. The shower's UK ZHR was 4–7 at best.

The final Perseids were picked up on August 20-21, although further observations continued up till August 30-31, making August by far the most heavily used month of 1993 for the *JASMS*.

3. Magnitude and train results

An analysis of Perseid and sporadic magnitudes and trains was carried out on the 851 Perseids and 295 sporadics seen by reliable UK observers under the clearest skies (limiting magnitude of 5.5 or better, and cloud cover less than 20%). Tables 1 and 2 give the global results for these sources.

Table 1 – Perseid and sporadic global magnitude distributions in August 1993

Magnitude	-3^-	-2	-1	0	+1	+2	+3	$+4^+$	Tot	$\overline{m}_{6.5}$
Perseids	30	32	46	129	172	186	169	87	851	2.1
Sporadics	3	3	8	18	38	60	90	75	295	3.2

Table 2 – Perseid and sporadic global train numbers (N_P and N_S, respectively), percentages (%), and mean durations in seconds (D) per magnitude interval

Magnitude	-3^-	-2	-1	0	+1	+2	+3	$+4^+$	Tot
N_P	24	27	39	76	85	55	19	2	327
$\%_P$	80	84	85	59	49	30	11	2	38
D_P	13.5	3.3	3.1	1.9	1.3	0.8	0.8	0.5	
N_S	2	0	0	3	6	2	2	0	15
$\%_S$	67	0	0	17	16	3	2	0	5
D_S	2.5			1.0	1.3	1.0	0.5		

As already noted above and elsewhere, the number of bright and trained Perseids appeared to be higher in 1993 than at other times in recent years, away from the outburst peaks seen in 1991 and 1992. For comparison with the above results, Tables 3 and 4 show combined global magnitude and train results from *JASMS* observations made in 1985, 1989, and 1991. Variations between these individual years were found to be insignificant.

Table 3 – Combined global Perseid and sporadic magnitude distributions from 1985, 1989, and 1991.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4^+$	Tot	$\overline{m}_{6.5}$
Perseids	58	69	126	278	371	432	457	306	2097	2.2
Sporadics	10	15	34	111	187	316	489	400	1562	3.1

Table 4 – Combined global Perseid and sporadic train data from 1985, 1989, and 1991. For explanations, see caption to Table 2.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4^+$	Tot
N_P	49	55	88	171	162	108	46	7	686
$\%_P$	85	80	70	62	44	25	10	2	33
D_P	7.2	2.7	2.1	1.9	1.4	1.2	0.7	0.4	
N_S	5	11	17	28	41	17	6	1	126
$\%_S$	50	73	50	25	22	5	1	0.3	8
D_S	6.0	1.9	1.6	1.4	1.1	1.1	1.4	0.8	

It is apparent that the statistics do largely bear out the colloquial reports of higher proportions of bright and trained Perseids this year than previously, although the difference overall seems relatively slight. Much of this difference can be attributed to August 11-12 alone, however. In fact, almost 84% of all the Perseids reported to the *JASMS* this summer were observed on August 11-12 (21%) or 12-13 (63%). Magnitude breakdown for the Perseids seen on these two nights are given in Table 5. The sporadics on both nights showed no real deviation beyond he normal spread for this source from the figures already given.

Table 5 – Perseid magnitude distributions for August 11-12 and 12-13, 1993.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3$	$+4^+$	Tot	$\overline{m}_{6.5}$
August 11-12, 1993	15	9	12	28	26	33	35	18	176	1.6
August 12-13, 1993	14	19	25	74	116	121	105	61	535	2.2

Normally, around 12% of Perseids seen in recent years fall into the brightness bin in excess of magnitude 0. For 1993 overall, this figure was 13%, not significantly altered with respect to this value, and indeed the results from August 12-13 (11%) bear this out. The data from August 11-12 paint a different picture, however, with no less than 21% negative magnitude Perseids present, roughly twice what would normally be expected. The fireball statistics show an even more marked alteration this year. The overall previous proportion of Perseid fireballs was 2.8%, compared to 3.5% for August 1993 (2.6% on August 12-13 only), but on August 11-12, the percentage was over three times higher than the mean value at 8.5%.

Not unexpectedly from the above, the Perseid train proportions were also higher in 1993. The mean value at the last few well-seen returns has been 33%, compared to 38% in 1993 as a whole (August 12-13 about 34%), but again the chief variation is due to August 11-12 alone, when 46% of all Perseids left persistent trains. There is no significant difference in mean Perseid train durations which cannot be accounted for by the relatively small numbers, however.

Conclusion

The summer of 1993 was an especially fruitful one for the *JASMS*, even though the main Perseid peak went largely unseen thanks to poor weather conditions in the UK. The most interesting facet of the data concerns the higher proportions of bright and trained meteors from the shower, presumably due to similar material detected at the past two outbursts in 1991 and 1992. The 1994 return is eagerly awaited!

Acknowledgments

I should like to thank all the named contributors in the above report for their support, time and efforts during the summer session.

An Overview of Compuserve Bulletin-Board Perseid Reports, 1993

Alastair McBeath

A brief review of a selection of the Compuserve computer bulletin-board Perseid reports is presented and discussed. Since these informal reports primarily come from a wide cross-section of the amateur astronomical community, they provide some information on the expectations and abilities of that group. This in turn provides data the *IMO* can use when dealing with future potential major events and planning press releases.

1. Introduction

In the immediate aftermath of the 1993 Perseid maximum, I was sent a large batch of some 116 Compuserve bulletin board reports by a *JAS* colleague, Ian Ridpath. These were recorded within 30 hours of August 11-12 at most, and on the whole, they gave a mixed picture of what activity had taken place. Indeed, several were rather misleading, as a result of observer inexperience or poor sky conditions not being taken into account. A lay-person with access to this same information only would probably have come away with the feeling that higher than normal Perseid activity had taken place, but that not everyone had seen it, even when separated by only a few tens or hundreds of kilometers. They would also have got the idea that the definite storm which was predicted to occur failed to take place.

IMO members will immediately realize from this just how misleading some of the reports were, and also how the media had twisted around what was actually stated in our own, and others', press releases. It must be realized, however, that the reports I received were not a complete set of all the Compuserve notices, nor were they necessarily chosen at random, since the idea was to provide me with an overview and flavor of what was on the bulletin board. The sample is thus not accurate for all the reports to Compuserve, but may at least be treated as a representative sample.

2. Analysis

Clearly, with many extremely vague reports, and almost none given with the full set of standard data in them, it was not possible to even contemplate a serious analysis. What was done instead was to look at the reports and extract some relevant features from each, where possible.

Six classes of data were decided upon:

1. the region the observers were in (by country);
2. the overall impression of the observing session;
3. the length of time observed for (usually approximately only);

4. the size of the groups involved;
5. comments on what Perseid activity was like (good, poor, or normal) and whether there were more or fewer bright meteors than usual; and
6. other notes, including any meteor sounds recorded and whether Perseids seemed to occur in bursts or not.

Each of the reports used was treated as either "serious," "semi-serious," or "casual," based solely on the information provided to Compuserve. A "serious" report contained data on the sky conditions (limiting magnitude, cloud, moonlight), the watch times, and at least the numbers of Perseid and other meteors seen per unit time. A "semi-serious" report contained at least a general comment on sky conditions with the number of meteors seen, while a "casual" report featured even less information than this—usually only a meteor count over a certain amount of time.

3. Results

Region

Table 1 gives a breakdown of reports per country. The percentages of serious, semi-serious, and casual observers from this were 9, 40, and 51, respectively. It is no great surprise that just over half the reports were from casual observers in light of the media coverage given to the Perseids in 1993. It is perhaps rather reassuring to note the small number of serious reports, in the sense that most serious observers were presumably either out recording what happened to the shower, preparing their data for analysis or recovering from their efforts, not spending time typing into a computer bulletin board! Just over 79% of the reports came from the USA, where a huge number of casual and semi-serious watchers were active as a result of a massive, if somewhat misguided, media circus.

Table 1 – Breakdown of Compuserve reports by country.

Country	Serious	Semi-serious	Casual	Total
Austria		1		1
Belgium			1	1
Canada	1		1	2
Finland	1			1
France		1	2	3
Germany	2	1	3	6
Iceland		1		1
Ireland		1	1	2
Norway	1			1
Scotland			2	2
Sweden			2	2
Switzerland		1	1	2
United States	6	40	46	92
Total	11	46	59	116

Impression

Table 2 gives details on the various observers' impressions of what they saw with no regard for experience or conditions. In total, 91 reports gave such impressions, just over 78% of the total number of notices. Most observers were at least satisfied with what they saw, and well over half were impressed with the display.

Table 2 – Impressions of the Perseid display.

Impression	Serious	Semi-serious	Casual	Total
Impressed	1	26	30	57
Neutral/OK	3	8	14	25
Unimpressed		4	4	8
Very unimpressed			1	1

Time observed

Table 3 records the average watch duration (a very approximate measure, as many non-serious reports were clearly not unbroken observations) reported to Compuserve. The decreasing watch duration with the seriousness of the observers is much as expected, but it was clear from some of the site locations given that several casual and semi-serious watchers had extended their efforts well into impossibly strong twilight. The 84 reports of watch times represents about 72% of the total body of notes.

Table 3 – Average time observed in hours, number of reports, and range of watch durations in hours.

Type	Time	Reports	Range
Serious	3.6	11	1.25–8
Semi-serious	2.7	35	0.7 –9
Casual	2.4	38	0.5 –6.5

Size of groups

Table 4 presents statistics for those 27 notices giving details on group sizes at a given location. This data came from just 23% of the reports. The small number of groups with stated sizes makes this information rather unreliable, though it is clear that larger groups tend to equate with more casual watchers. The huge groups found at several locations in the USA appear to have gathered more or less spontaneously at supposedly dark-sky sites, often to the detriment of all, with car headlights making even seeing the night sky very difficult for much of the time.

Table 4 – Average group sizes, total number of groups, and size range.

Type	Size	Groups	Range
Serious	63	2	5– 120
Semi-serious	44	14	2– 400
Casual	205	11	2–1000+

Perseid rates

Table 5 shows what observers thought of the Perseid activity, and whether more or fewer bright shower members were present than on average. The 0.5 of the casual, good, and poor columns is due to one observer whose anonymity is retained, who reported Perseid rates of one meteor per minute, but was most disappointed at the low activity he saw, and commented that it was not a shower at all! The vast majority disagreed with this view, however, with well over half the 82 reports noting good Perseid numbers, and virtually all of the 60 notices that did so recording many more bright Perseids than expected. Several of these were exceptionally brilliant fireballs, and at least two meteors left three-minute persistent trains.

Table 5 – Perseid activity reported, and whether many or few bright Perseids were detected.

Activity	Serious	Semi-serious	Casual	Total
Good	2	22	21.5	45.5
Normal	3	6	10	19
Poor		5	12.5	17.5
Many bright	6	21	31	58
Few bright		1	1	2

Notes

Fourteen observers (8 semi-serious, 6 casual) noted that the Perseids seemed to occur in bursts, although the gap between such bursts was put variously at between 2–30 minutes. With an undoubtedly large number of accurate meteor timings available this year, this is perhaps one facet of the shower the *IMO* analysts may wish to examine further in the final report. Simultaneous sounds (primarily hissing or whooshing) were reported by two observers (1 semi-serious, 1 casual), although neither meteor appeared to be particularly bright. One semi-serious report of acoustic sound heard some time after a meteor was also given.

4. Conclusions

Overall, then, it seems the less serious observers of an event such as the 1993 Perseids, and prepared to report their findings to a computer bulletin board, are most likely to be American, and are especially interested in reporting their impressions of what they saw, how long they observed for, and how many meteors they recorded. They are likely to watch on average for a little over two hours, and unless warned in advance (which does not seem to have happened through the media this time), are likely to observe in the early evening hours with no regard for how low the radiant may be. Indeed, many seemed to be quite unaware of where the Perseids would radiate from, and some recorded their congratulations to whoever predicted the meteors would be emanating from Perseus/Cassiopeia! Equally, a few did not feel the meteors to be coming from anywhere in particular in the sky. Quite a number of observers were disappointed while watching from totally unsuitable city sites (again perhaps because the media had not mentioned the need for dark skies), or with a lot of cloud or haze, but on the other hand, some allowed for these problems, and were quite pleased to see anything at all. Clearly, the effect of the shower depended to a large extent on prior expectations. Almost none of the Americans seemed to appreciate that the best available predictions in advance of the event suggested Europe would be the place to observe from in 1993. Many did comment that they are looking forward to the 1994 return.

For the future, we can note that the press release campaign worked well, in that a large number of people were aware of the event, and meteors may at least have crossed the consciousness of the general public for the first time in many years. We do need to ensure that we keep the notes clear and simple, and that important facts, such as when the radiant is at a useful elevation, are clearly stated. This will be particularly necessary for the Leonids, whose radiant is below most observers' horizons until after local midnight, for example. Once the press take hold of a story, there is no knowing what they will do with it. In this instance, certain key features were often easily overlooked or ignored (dark skies, after-midnight watches, only the possibility of a storm, etc.), and it might be as well to include a numbered checklist in future press notices covering the vital items for a casual audience. On the whole, the main points do seem to have got across to the general astronomical grouping represented here. The dissenters are probably people who would misinterpret almost anything that was told to them in cases like this, or who raised their expectations too high. It will be interesting to see what is made of the 1994 return.

Crimean 1993 Fall Observations

Andrey Grishchenyuk

An overview is given of Crimean observations of the 1993 Orionids, Leonids, and Geminids.

Crimean amateur astronomers carried out observations of the Orionid Meteor Shower between October 20 and 23, 1993. Observing conditions were not that good (limiting magnitude between 5.4 and 5.8) and relatively few meteors were registered: 10 to 12 per hour. After corrections for observing conditions, however, ZHRs were considerably higher—about 80. During the night of October 21-22, we also noted unusually high activity seemingly radiating from near θ UMa. Unfortunately, we were not able to determine the radiant's position more accurately. This radiant peaked at about ZHR 15, while the nights before and after the ZHR was about 1.5–2. Meteors were mostly bright and yellow, and had no train.

During the night of November 18-19 and 19-20, we also observed the Leonid shower. The observational conditions made good observing difficult: temperature was $-15°$ C to $-20°$ C, while limiting magnitudes were 5.8 to 6.0. Few meteors were recorded. The first night, 12 Leonids from a total of 34 recorded meteors were registered, over a period of 2.67 hours net observing time. The second night brought us 6 Leonids (from a total of 19 meteors, over 1.62 hours of observing time). The brightest meteor was a Leonid of magnitude -8 to -10. It was recorded at 2^h46^m UT during the night of November 19-20. It had a train that lasted 20 seconds.

During the night of December 13-14, we observed the Geminids. Observing conditions were bad (limiting magnitude between 5.3 and 5.5). In total, 46 Geminids were detected in the period 20^h45^m–21^h35^m UT by Suchov, an experienced observer. This time activity was more impressive. The other nights we were clouded out.

The 1993 Leonids in Jordan

Khalil Konsul and Ala' Shahin

An overview is given of Jordanian observations of the 1993 Leonids.

In response to the *International Leonid Watch Bulletin* (*WGN* 21:5), the *Jordanian Amateur Astronomers Society (JAAS)* organized an observing camp on the night of November 17-18, 1993, for observing the 1993 Leonids. The camp was held in the heart of the desert near the Al-Azraq Oases, about 150 km east of the capital city of Amman. The coordinates of the observing site are $\lambda = 37°06'50''$ E and $\varphi = 31°43'00''$ N. The participants were as follows:

> Khalil Konsul, Khalid Tell, Ala' Shahin (SHAAL), Sana' Abdoh, Mohmad Abdoh, Eyad Mustafa, Ahmad Dhiab, and Ayman Akasheh.

The desert observing conditions were excellent; the clear skies provided spectacular and ideal view of the Leonids.

The observing session began at 23^h31^m and ended at 2^h16^m UT. Table 1 shows an individual magnitude distribution for the whole session time, an Table 2 gives rate information for an individual observation.

Zodiacal light was obvious during the observing session with 20° width at the horizon and the nose of the cone near β Leo (Denebola). One of the spectacular events was a sporadic fireball of magnitude -4 with a persistent train of 2 s. Another spectacular event was a sporadic fragmenting meteor: three fragments were observed, each having its own persistent train. Another strange meteor was a blood-red sporadic without definite train.

Table 1 – Magnitude distribution for the 1993 Leonids from a Jordanian observation

Shower	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot
Leonids	0	0	6	6	15	14	10	5	4	1	0	61
Sporadics	1	0	0	1	5	18	8	6	16	13	1	69

Table 2 – Rate data for the 1993 Leonids from a Jordanian observation. The center of the field of view is also given. All data were obtained by the counting method.

Period (UT)	α	δ	$T_{\rm eff}$	F	Lm	Leo	Spor
23^h31^m–00^h45^m	135°	+30°	$1^h\!.23$	1.00	6.1	18	38
00^h45^m–02^h16^m	135°	+30°	$1^h\!.52$	1.00	6.2	43	31

BAA Observations of the 1993 Geminids

A Preliminary Report

Neil Bone

An overview is given of *BAA* observations of the 1993 Geminids.

Observers contributing to the *BAA Meteor Section* have enjoyed some success in covering the Geminids in recent years, notably 1985 [1], 1988 [2], and 1991 [4]. These results extend a series stretching back to the 1960s and earlier. Moonlight conditions were favorable for the 1993 return, and *BAA* observers were again provided with project details [5]. As of mid January 1994, results had been received from the 40 observers and 1 group of observers listed below for nights between December 7-8 and December 16-17, 1993:

R. Billington, N. Bone, D. Briggs, K. Brill, D. Bruton (USA), G. Bryant, J. Campos (Portugal), O. Cauldfield (Ireland), P. Craven (Finland), B. Ewen-Smith (Portugal), M. Green, C. Hall, S. Evans, M. Flowers, D. Gavine, I. Gray, P. Haworth, T. Higgins, C. Jenkins, P. Jenkins, R. Johnson, B. Kelly, N. Kierman, J. Lancashire, A. McBeath, T. Markham, R. Minty, S. Moore, T. Mosely, G. Parseley, A. Pratt, N. Raynder, R. Schmude (USA), G. Simmons, G. Spalding, C. Steele, D. Strachan, M. Taylor, I. Wood, P. Yates, and Isle of Man Astronomical Society (7 observers).

In all, 3804 meteors, including 3139 Geminids and 647 sporadics have been reported, from 140^h14^m watch time.

As is often the case in mid-December in Northwest Europe, weather was the dominant influence. The British Isles were clouded out on December 12-13, for example, and no observations have been received for that night. However, a cold front cleared southwards across the country on maximum night, December 13-14, providing excellent conditions at many sites; observations from this night comprise the bulk of material received. It would seem that UK observers were lucky to escape the clouds which covered mainland Europe [6]. While a night-by-night picture of Geminid activity in 1993 cannot be presented, it should at least be possible to ascertain the hourly changes around the expected time of maximum.

Visual results from experienced observers under the best skies on December 13-14 were binned in 1-hour intervals, and average rates determined, then corrected to yield ZHRs allowing for radiant elevation, and limiting magnitude. Population index values $r = 2.44$ for Geminids and $r = 3.42$ for sporadics were used, after Spalding [7]. ZHR values are presented in Table 2. Whole-night averages are given for dates other than maximum.

Table 1 – *BAA* observations of the 1993 Geminids. Solar longitudes refer to eq. 2000.0.

Date	Time (UT)	$\lambda_\odot$	$T_{\rm eff}$	$\overline{\rm Lm}$	Spor	HR	Gem	$h_{\rm rad}$	ZHR
Dec 07	22^h36^m	255°93	13^h00	5.87	58	9.7 ± 1.3	21	54°3	3.5 ± 0.8
11	00^h12^m	259°05	6^h00	5.63	26	13.2 ± 2.6	40	60°8	17.2 ± 2.7
11	23^h31^m	260°04	12^h00	5.65	77	19.0 ± 2.2	70	55°7	15.4 ± 1.8
13	20^h30^m	261°94	3^h00	6.10	8	4.4 ± 1.6	79	30°1	75.0 ± 8.4
13	21^h20^m	261°98	3^h00	6.17	11	5.5 ± 1.7	64	37°2	47.4 ± 5.9
13	22^h20^m	262°02	6^h20	5.95	44	15.1 ± 2.3	214	45°9	81.2 ± 5.6
13	23^h36^m	262°07	6^h00	5.91	13	4.5 ± 1.2	236	56°2	80.1 ± 5.2
14	00^h33^m	262°11	8^h00	5.98	44	10.4 ± 1.6	322	63°4	72.9 ± 4.1
14	01^h07^m	262°14	6^h00	5.97	35	11.2 ± 1.9	266	66°5	77.6 ± 4.8
14	02^h24^m	262°19	7^h00	5.84	38	11.8 ± 1.9	292	68°4	72.5 ± 4.2
14	03^h21^m	262°23	7^h00	5.71	34	12.0 ± 2.1	297	64°8	90.7 ± 5.3
14	04^h21^m	262°27	7^h15	5.81	43	13.5 ± 2.1	292	57°1	90.0 ± 5.3
14	05^h25^m	262°32	5^h00	5.74	26	13.4 ± 2.6	141	47°6	76.6 ± 6.5
14	06^h05^m	262°35	1^h00	6.00	3	7.8 ± 4.5	22	41°4	73.2 ± 15.6
14	07^h13^m	262°40	2^h00	6.00	4	3.7 ± 1.8	79	75°4	63.8 ± 7.2
14	22^h04^m	263°03	3^h00	5.73	12	10.3 ± 3.0	31	44°3	29.4 ± 5.3
16	22^m53^m	265°10	3^h00	5.68	22	20.1 ± 4.3	8	52°6	7.0 ± 2.5

On the basis of results from 1990 and 1991, maximum was expected around $\lambda_\odot = 262°0$ (eq. 2000.0) (22^h UT) [8]. Geminid activity seems to have been quite steady, on the whole, *perhaps* peaking around ZHR 90–95 about 2^h–3^h UT ($\lambda_\odot = 262°25$). By dawn, rates were possibly starting to decline; many observers have commented that activity appeared to be dropping off later in the night. Several experienced observers recorded "bursts" of Geminids—up to 6 meteors per minute—around midnight UT. The calculated peak ZHR values are comparable to those found in 1991 [4,9].

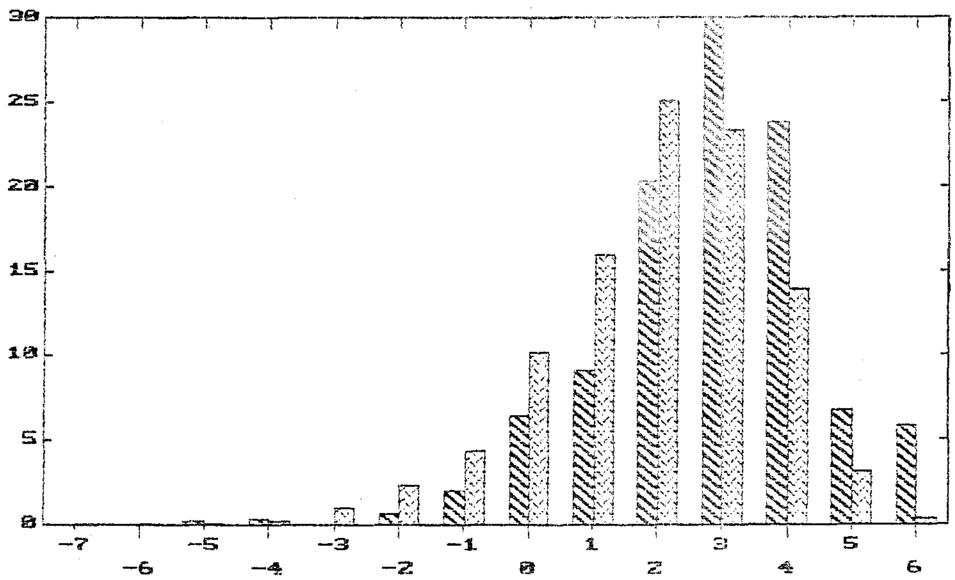

Figure 1 – 1993 relative Geminid and sporadic magnitude distributions obtained from *BAA* observations. For each magnitude class, first the percentage of sporadic meteors and then the percentage of Geminid meteors is given. The distribution is based on 618 sporadics and 2827 Geminids.

Magnitude estimates for Geminids and sporadics for all nights are summarized in Figure 1. An excess of bright Geminids relative to the contemporaneous sporadic background is clearly seen. Mean magnitudes were 2.0 and 2.7 for Geminids and sporadics, respectively.

As usual, few Geminids (5.3%) left persistent trains. For comparison, trains were left by 6.4% of sporadics.

In addition to visual observations, a considerable amount of photography was carried out with the aim of extending previously-reported radiant analyses [3,4]. With some observers' films remaining to be processed, indications are that dozens of Geminid trails suitable for measurement have been recorded. Steve Evans operated a spectrograph on December 13-14, recording a single, 3-line, Geminid spectrum. Andrew Elliott carried out some further low-light video camera recording to provide accurate meteor timings [10].

Overall, the 1993 Geminids proved a success for the *BAA Meteor Section*. At the time of writing, reports were still trickling in, and the results presented here must be regarded as preliminary. We would anticipate preparation of a final analysis on both visual and photographic results for the *Journal of the BAA* by the end of the year.

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The 1993 Geminids over Sliven, Bulgaria

Ivanka Getsova and Atanas Nikolov

An overview is given of Bulgarian observations of the 1993 Geminids.

After we had watched the Geminids between holes in the clouds in 1991 and we had not seen them at all in 1992, the weather on the night of December 13-14, 1993, was comparatively good. Our team was, as usual, Atanas Nikolov, Galina Dimitrova, Ivanka Getsova, Krasimir Manov and Peter Dalakov. The shower slowly gained activity and after 24^h UT on December 14, the number of shower meteors visibly increased: bright (magnitude 0 or -1) and weak (magnitude 4 or 5) stationary Geminids were observed around Castor. For the whole interval of observations, the average magnitudes are 1.8 for the Geminids and 2.5 for the sporadics. The limiting magnitude for the different observers varied between 5.7 and 6.1.

The average ZHRs for the Geminids are given below:

Table 1 – Average 1993 Geminid ZHRs from Bulgarian observations.

Period (UT)	ZHR
19^h30^m–20^h30^m	23 ± 1
20^h30^m–21^h30^m	61 ± 5
21^h30^m–23^h00^m	70 ± 8
23^h45^m–00^h45^m	75 ± 9
00^h45^m–02^h00^m	60 ± 2

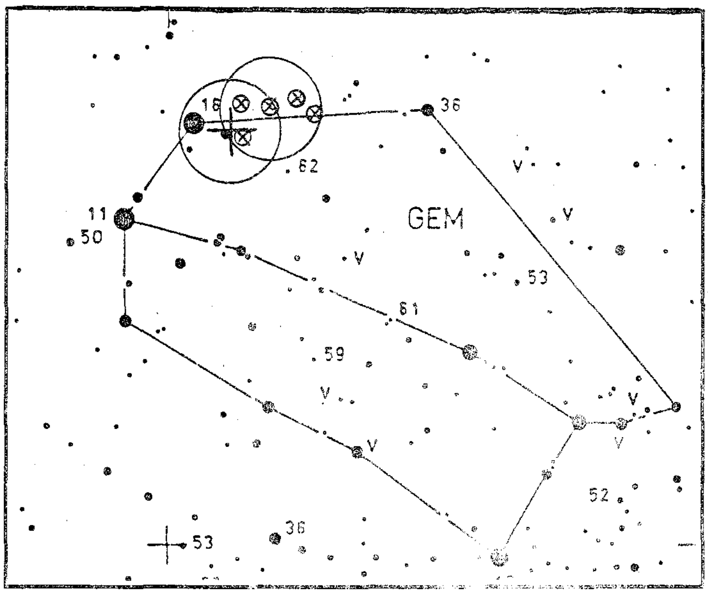

Figure 1 – Radiant determination of the 1993 Geminids using stationary meteors.

Using 5 stationary meteors (see Figure 1) observed by Atanas Nikolov on December 13, 1993, between 22^h30^m and 22^h36^m UT, the coordinates of the radiant of the Geminids were determined as $\alpha = 110°$ and $\delta = +34°$. The coordinates of the radiant position for the date of the maximum are plotted for a comparison. They are (marked with a plus on the map) $\alpha = 112°$ and $\delta = +33°$.

After 24^h UT on December 13, 1993, the radiant of the σ-Hydrids culminated at 45° elevation, and we observed several meteors of this shower. The average ZHR equaled 5 for the interval 0^h45^m–2^h00^m UT.

Next time:

Although this is a thick issue, we were nevertheless forced to yet postpone a few submissions to the June issue. This is due to the fact that for cost-efficiency reasons the present issue is mailed together with the Proceedings of the 1993 IMC *to the participants of this meeting—to do so, we had to limit the size of this issue to 54 pages.*

Therefore, we anticipate the June issue will be thick again, that is, if you keep submitting contributions! Also note that the **Index of Volume 21** (1993) *will be mailed together with the June issue.*

The International Meteor Organization

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International Meteor Conference 1994

Belogradchik, Bulgaria, September 22–25, 1994

The 1994 International Meteor Conference will take place in Belogradchik, in the northwestern part of Bulgaria, in most beautiful surroundings.

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But do not hesitate any longer! In Belogradchik, there is overnight accommodation for only 60 persons, limiting the number of participants.

Contact Paul Roggemans immediately if you do not want to miss this unique event! It would be a pity if you could not participate in the 1994 *IMC* just because you returned your form late!

As usual, the *IMO* will publish proceedings of this *IMC*.

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Puimichel, Southern France, September 23–26, 1993

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These proceedings are published by the *International Meteor Organization* and can be ordered at only 12 DEM per copy (surface mail delivery). Note that the proceedings were included in the registration fee for the participants of the 1993 *IMC*; they should have received their copy together with this issue. Non-participants can order these proceedings in the same way as paying for *WGN*!