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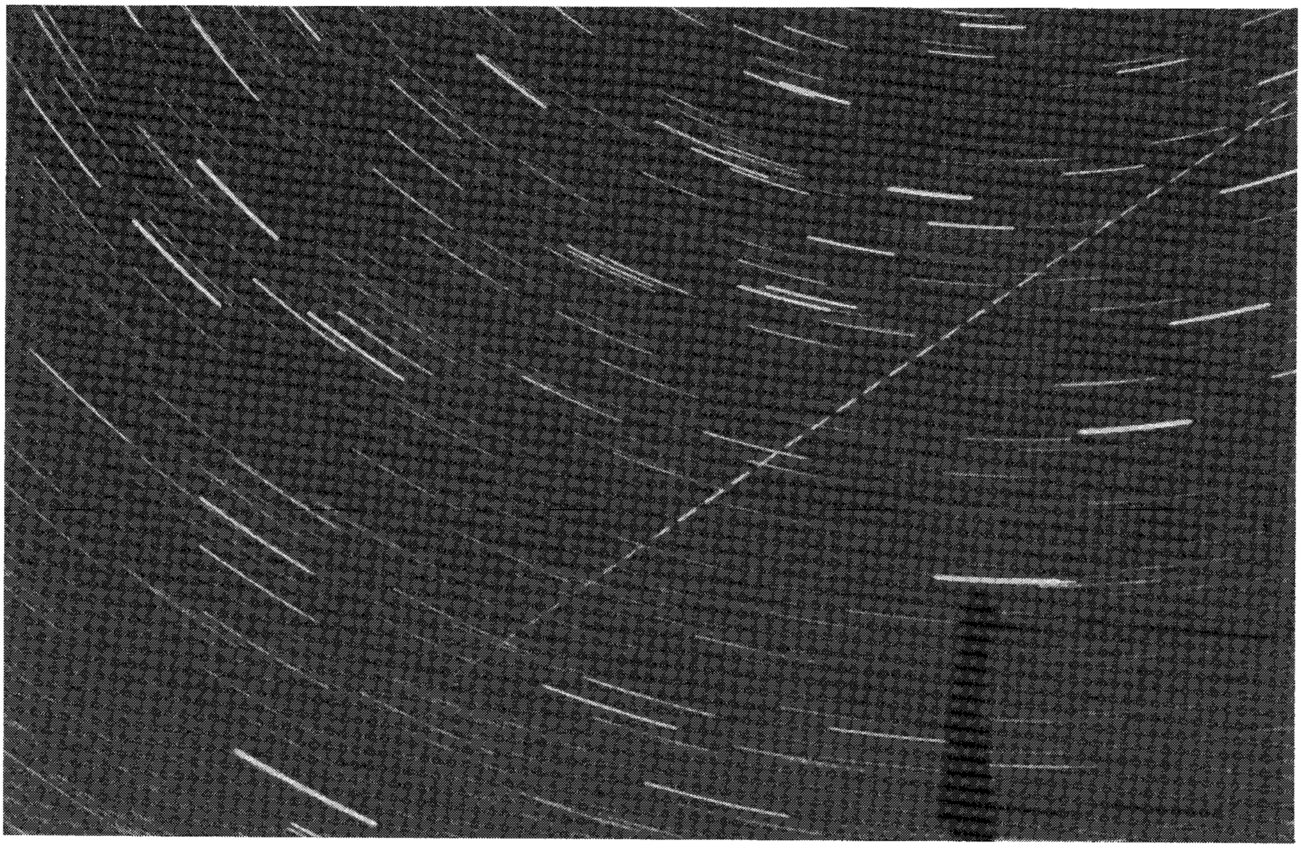

A magnitude −2 Geminid in Ursa Minor, photographed by Casper ter Kuile in Lardiers, Southern France, on December 13, 1990, at $21^h02^m26^s$ UT. Other Geminid photographs by the same author can be found inside this issue as well as on the cover of volume 3 of *WGN*'s *Observational Report Series* (see outside back cover for more information).

In this issue:
- Practical information for observers
- Global analysis of the 1990 Orionids
- On the characteristics of fireballs
- Observational results

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v.u.: Marc Gyssens, Heerbaan 74, B-2530 Boechout, Belgium

Afgiftekantoor: 2540 Hove

WGN, volume 19, nr 4, August 1991, pp. 105–168

Contents

Useful Information

The October Issue *(WGN 19:5)*

The *October issue* is expected to be mailed during the second week of October. Contributions are due *September 22*. They should be sent to *Marc Gyssens* or to any member of the editorial board (addresses: inside of back cover), or given to *Marc Gyssens* at the 1991 *IMC* in Potsdam, preferably on diskette. The editor-in-chief will carry empty diskettes with him which will be given in return for articles submitted on diskette.

From the Editor-in-Chief

Marc Gyssens

This issue contains another global shower analysis, as promised. Ralf Koschack and Paul Roggemans focused on the 1990 Orionids, resulting in article of over 15 pages! As similar analyses are to be published in about each issue, it is to be expected that space problems will re-occur. To alleviate this problem, we have decided to publish the purely informative articles (editorial, letters, notes from the commissions, observers' notes, information about and reports of meetings, etc.) in smaller print, saving us at least two pages per issue and providing you extra information at the same cost.

In this issue, you will also read about the Fourth Conference on Asteroids, Comets and Meteors that took place last June in Flagstaff, Arizona. Among other things, it was decided there to select six consultants from amateur meteor organizations to function in a working group on amateur-professional cooperation in the context of IAU Commission 22. IMO will provide three out of these six consultants! Surely, this decision constitutes yet another milestone in the history of IMO and the achievements of its aims.

Nevertheless, I would like to warn once more against euphoria. IMO has grown quite strong now on the "visual front". As various analyses published in WGN show, we really have something to offer to the professional community in this field. However, IMO is not and cannot be an organization for visual meteor observations alone. It should therefore be one of IMO's chief priorities to develop the other branches of meteor astronomy to the same level the visual branch has reached now. Let us all join our efforts to realize that goal in the near future!

Letters to WGN

compiled by Marc Gyssens

The Glatton Meteorite

Shortly after the completion of the June issue, we received another article on the impact of the Glatton meteorite in England from Noel White. Mr. White was only a 45 minute journey away from the village of Glatton. However, most of the information provided by Mr. White was already covered by Mr. Shanklin in the previous issue and will therefore not be repeated here. Nevertheless, Mr. White's report also contains an interesting comparison with the fall of the Barwell meteorite in 1965 (also mentioned in the article on pp. 100–101 of the previous issue) that we are pleased to reproduce below. When this event occurred, Mr. White happened to be just a few miles away from the place of impact, which enabled him to interview eyewitnesses.

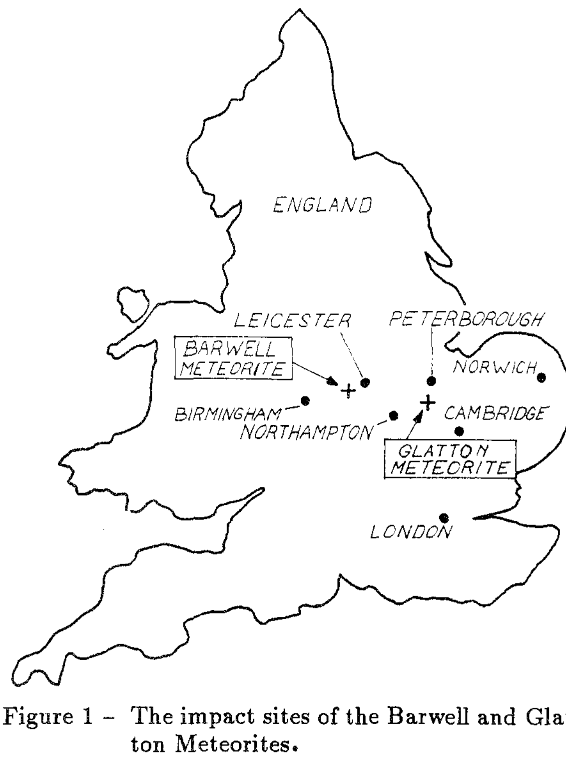

Figure 1 – The impact sites of the Barwell and Glatton Meteorites.

It is interesting to compare the Glatton Meteorite with the last one to fall on the UK on December 24, 1965, at approximately 17^h15^m UT, in the village of Barwell, near Leicester, $\lambda = 1.^\circ342$ W, $\beta = 52.^\circ568$ N. The Barwell Meteorite was probably of a softer composition and broke into several pieces in its passage through the atmosphere.

Two of the main pieces fell about half a kilometer apart, while another piece made a hole in the bonnet of a car and another broke the window of a house. When touched, it was warm, not hot. Yet another piece fell on a tarmac road and left a grey powder which was still present when I was there.

Eyewitnesses told me that at least six loud whistling sounds and detonations were heard and a bright fireball which increased in brilliance above the apex of a house opposite indicated that the meteorite came from the NNE at an approximate altitude of 35°.

A total of 22 kg was recovered and when fitted together formed an irregular piece measuring approximately 38 cm long by approximately 18 cm.

Noel White, June 9, 1991

Important Notes from the Radio Commission

Jeroen Van Wassenhove

In order to reduce radio data in an acceptable period of time, I ask all observers to send in their observations *within four months* after the observations. At this moment, radio data from a year ago are still coming in. So please, do respect this time schedule.

The Radio Commission has a complete set of standard observing forms. So, please *use the standard IMO radio forms* and not your local observing forms. The conversion to the *IMO* standard costs us a lot of precious time and is a never-ending source of problems. The forms are available at the Radio Commission. They are free of charge! So please use them!

People who send in observations on a diskette should use the *RMDB* format, which is is available from the Radio Commission.

Recently, a new version (release 3.02) of the *FORWARD* program has become available. One of the main enhancements is the dBase interface. It allows one to completely automatize the calculation for different stations. The program can be obtained from the Radio Commission. In order to keep costs down, please enclose a self-addressed envelope and a 360 kB, $5\frac{1}{4}''$ MS-DOS diskette.

Visual Observers' Notes: September–October 1991

Jeff Wood and Ralf Koschack

1. Introduction

Following the excellent activity of the previous two months, observers tend to feel let down when rates return to normal during September and October. Because of this, nowhere near as much observational work has been carried out during this time even though there is much to see.

Table 1 gives a list of the active showers that occur in these months and Table 2 shows the observing conditions moon-wise. 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.

For more details, we refer to the *IMO 1991 Meteor Shower Calendar*. Here we highlight some of the showers visible during September and October.

Table 1 – A list of meteor showers to be seen during September and October 1991.

Shower	Activity	Max	Radiant			Drift		V_∞	r	ZHR
			α	δ	Diam.	$\Delta\alpha$	$\Delta\delta$			
π-Eridanids	Aug 20–Sep 05	Aug 29	52°	−15°	6°	+0.°8	+0.°2	59	2.8	
α-Aurigids	Aug 24–Sep 05	Sep 01	84°	+42°	5°	+1.°1	0.°0	66	2.5	15
δ-Aurigids	Sep 05–Oct 10	Sep 10	60°	+47°	5°	+1.°0	0.°1	64	3.0	7
Piscids S	Aug 15–Oct 14	Sep 21	8°	0°0	8°	+0.°9	+0.°2	26	3.0	3
κ-Aquarids	Sep 08–Sep 30	Sep 22	339°	−02°	5°	+1.°0	+0.°2	16	3.0	3
Capricornids (Oct)	Sep 20–Oct 14	Oct 03	303°	−10°	5°	+0.°8	+0.°2	15	2.8	3
σ-Orionids	Sep 10–Oct 26	Oct 05	86°	−03°	5°	+1.°2	0.°0	65	3.0	3
Draconids	Oct 06–Oct 10	Oct 10	262°	+54°	5°			20	2.6	
ε-Geminids	Oct 14–Oct 27	Oct 20	104°	+27°	5°	+1.°0	0.°0	71	3.0	5
Orionids	Oct 02–Nov 07	Oct 21	95°	+16°	10°	+1.°2	+0.°1	66	2.9	30
Taurids S	Sep 15–Nov 26	Nov 03	50°	+13°	10°/5°			27	2.3	12
Taurids N	Sep 13–Dec 01	Nov 13	58°	+22°	10°/5°			29	2.3	8
Puppid/Velids	Oct 15–Jan 22	several	120°	−45°	20°/5°			40	2.9	

Table 2 – Moonlight and observing conditions in September–October 1991.

Date	k	Date	k
Friday August 30	0.79–	Friday October 4	0.18–
Friday September 6	0.08–	Friday October 11	0.11+
Friday September 13	0.23+	Friday October 18	0.71+
Friday September 20	0.85+	Friday October 25	0.97–
Friday September 27	0.89–	Friday November 1	0.31–

New Moon:	September 8, October 7, November 6
First Quarter:	September 15, October 15, November 14
Full Moon:	August 25, September 23, October 23
Last Quarter:	September 1, October 1, October 30

Table 4 shows the relationship between angular velocity, altitude and radiant distance of a meteor for various values of a meteor stream's geocentric velocity, as published in [1]. As this relationship must be carefully taken into account when identifying shower meteors, we re-publish this information here as a courtesy to the readers who joined us this year.

2. Southern Piscids

This weak ecliptic stream is active from August 15 through to October 14. Rates are generally one or two meteors per hour, but on occasions have passed 5 per hour around the maximum which occurs on September 21.

With a Full Moon occurring on September 23, the Piscids can be best observed under dark sky conditions from the southern hemisphere during the periods September 1–15 and September 28–October 14. Observers should face the radiant area and plot all Southern Piscids seen taking care to distinguish them from the sporadic background.

Table 3 – Radiant positions of the Southern Piscids.

Date	α	δ	Date	α	δ
Sep 15	0°	−02°	Sep 30	13°	+01°
Sep 20	4°	−01°	Oct 05	17°	+02°
Sep 25	9°	00°	Oct 15	26°	+04°

3. κ-Aquarids

This minor ecliptical stream has an activity period from September 8 to 30. It reaches a maximum ZHR of 3 on September 22. Since its period of activity and its radiant position is similar to that of the Southern Piscids, both showers can be observed simultaneously. In 1991, the Full Moon on September 23 means that the κ-Aquarids can be observed under dark sky conditions from September 8 to 14. Southern hemisphere observers should make their center of field of view somewhere around $\alpha = 345°$ to $0°$ and $\delta = -20°$ to $+20°$. All possible shower meteors should be plotted. Shower association should be carried out very carefully taking note of direction of travel, path length and appropriate angular velocity.

4. δ-Aurigids

As the observing circumstances for the Southern Piscids and the κ-Aquarids are rather unfavorable this year, we do not encourage northern hemisphere observers to watch these showers. They will be much more successful with the δ-Aurigids.

Indeed, the radiant of this minor shower is well situated for observers in the northern hemisphere. The fast ($V_\infty = 64$ km/s) Perseid-like meteors are very striking and the ZHR reaches values of about 7 around September 10. But after more or less successful Perseid campaigns, most observers rest on their laurels at that time. That is why our knowledge of this shower is rather poor. With New Moon on September 8, the conditions to monitor its activity are very favorable in 1991. Observers in the northern hemisphere are called upon to pay special attention to this shower in their September observations. Except for the first two hours after dusk, the radiant is sufficiently high in the sky for useful observations with the best conditions in the morning when the radiant approaches the zenith of mid-northern latitudes. Therefore, the morning hours should be preferred for observations. Choose the center of your field of view at about 20° to 30° from the radiant.

Table 4 – Angular velocity (°/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				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	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				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	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				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	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				
	$h_b = 10°$	20°	40°	60°	90°	10°	20°	40°	60°	90°
$D = 5°$	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				
	$h_b = 10°$	20°	40°	60°	90°
$D = 5°$	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

All possible δ-Aurigids should be plotted. For final shower association to be carried out at the desk, take into account all criteria (direction and length of the path, angular velocity), using Table 4. Table 5 shows the position of the δ-Aurigid radiant throughout its activity period.

Table 5 – Radiant positions of the δ-Aurigids.

Date	α	δ	Date	α	δ
Sep 01	51°	+46°	Sep 20	70°	+48°
Sep 10	60°	+47°			

5. October Capricornids

The October Capricornids were discovered in 1972 and provide variable activity from year to year. They are active from September 20 through to October 14 with an overall maximum on October 3. With a Full Moon on September 23 the maximum period of their activity will have dark skies. Intending observers should ensure that they face the radiant position and plot all possible shower meteors. Care should be taken in identifying these meteors. At maximum the October Capricornid radiant is situated at $\alpha = 303°$ and $\delta = -10°$.

6. Comet Findlay radiant

Observations during September and October have indicated that there is some evidence of meteor activity from the area of the predicted Comet Findlay radiant. Although there will be some interference from the Moon during late September, southern hemisphere observers are requested to make observations of the Comet Findlay radiant a priority in 1991. Since they can be observed simultaneously with the October Capricornids, southern observers should endeavor to monitor both. To do this they should have a center of field of view situated around $\alpha = 285°$ and $\delta = -20°$, which is midway between both shower radiants. The Comet Findlay radiant should be monitored from September 25 through to October 15. The radiant area is from $\alpha = 260°$ to $280°$ and $\delta = -30°$ to $-42°$. All possible shower members should be plotted and great care should be taken in identifying any meteors coming from the radiant area as such.

7. σ-Orionids

This shower is active from September 10 through to October 26. Its maximum ZHR of 3 meteors per hour occurs on October 5 which means that the Moon does not interfere with the strongest period of activity in 1991. The σ-Orionids have their radiant in the Belt of Orion and so after maximum great care needs to be taken to distinguish them from the October Orionids. This year, the *IMO* is particularly interested in the σ-Orionid activity profile for the period September 29 to October 16 when the skies should be almost moon-free.

Observers in both hemispheres should watch during the last few hours before sunrise and have a center of field situated no more than 30° west or northwest of the radiant. All possible shower members should be plotted and care taken in identifying them.

Table 6 – Radiant positions of the σ-Orionids.

Date	α	δ	Date	α	δ
Sep 15	71°	−03°	Oct 15	93°	−03°
Sep 25	79°	−03°	Oct 25	101°	−03°
Oct 05	86°	−03°			

8. Draconids

The October Draconids reach a sharp predicted maximum at 22^h UT on October 10. In 1991, moon-free skies make this period shower a must for monitoring. The Draconids can only be seen from the northern hemisphere and provide extremely variable rates from the ZHR 0 to storm proportions. Situated at a radiant of $\alpha = 262°$ an $\delta = +54°$, the Draconids should be monitored from October 7 to 11 to see if there are any unusual outbursts of activity (probably unlikely) and to determine the structure of the stream. Intending observers should plot all stream members seen unless the ZHR rises above 10 when classified counts may be taken. They should have their center of field of view located no more than 40° from the radiant position. The diameter of the Draconid radiant is 5°. The geocentric velocity of the Draconids equals $V_\infty = 20$ km/s. Please use Table 4 for shower membership identification.

9. Orionids

This major shower will have very unfavorable moon conditions in 1991 with the Full Moon occurring on October 23. The Orionids have a complex radiant structure with the center of activity being located just north of the star Betelgeuse at maximum. The Orionids are associated with Comet Halley and, like the η-Aquarids, display a plateau-like maximum. This can vary from year to year but is generally from October 20 to 25. The Orionid maximum occurs on October 22 with a ZHR that is usually in the range of 20 to 30 meteors per hour. Orionids are best observed during the latter part of the night when the radiant altitude rises above 20°. They are observable in both hemispheres and all possible Orionid meteors should be plotted unless the ZHR exceeds 10. Thereafter, classified counts may be taken.

10. Taurids

This shower is broken up into several substreams, the most important of which are called the Northern and the Southern Taurids respectively. The Taurids have one of the longest periods of activity known and last from September 13 through to December 1. They reach a broad maximum in late October and early November. The maximum of November 3 (Southern Taurids) and November 13 (Northern Taurids) given in the radiant list were derived from radio meteor and photographic meteor orbital elements and not visual observations. The latter give an uncertain picture. At maximum, Taurid activity is often very erratic with rates ranging from 1–2 meteors per hour to as high as 10 or 15 meteors per hour.

In September and October, the Taurids are best observed during the middle and latter parts of the night. They are noted for their many fireballs. These are frequently yellow and orange in color, but all of the other colors are also well represented. This together with their relatively low geocentric velocity means that they can be recorded more easily on film than most other showers. Perhaps you could try and photograph some for the *IMO Photographic Meteor Database*.

Since they have a great longevity of activity, the Taurids have parts of their activity period moon-free and others greatly affected by the Moon. They can be easily seen from both hemispheres. When observing the Taurids, all possible shower members should be plotted. In order to distinguish meteors from the both branches the center of field of view should be located between 20° and 40° east or west of the radiant at the same declination.

In September the most favorable center of field of view is around $\alpha = 0°$ and $\delta = +10°$ to $+15°$. This way, κ-Aquarid, Southern Piscid, Northern Taurid and Southern Taurid radiants can all be observed simultaneously. In October the most favorable field of view is located at $\alpha = 80°$ and $\delta = +20°$ which enables both the Taurid radiants together with the Orionid, σ-Orionid and the ε-Geminid radiant to be monitored at the same time. The *IMO* is particularly looking to obtain Taurid ZHR profiles and to investigate the population index during the 1991 Taurid watch.

Reference

[1] R. Koschack, "Estimating a Meteor's Angular Velocity", *WGN* 18:4, August 1990, pp. 103–104.

Telescopic Observers' Notes: September–October 1991

Malcolm J. Currie

Again there have been disappointingly few telescopic observations reported since the last set of notes. However, David Swann has reported a burst of activity of five meteors, including a possible "head-on" event, on July 4, 1991, from 03^h55^m to 04^h10^m UT in the Draco region. The four moving meteors appeared to radiate from the position of the stationary meteor, which also coincided with a magnitude 7.5 star. The increased brilliance of the star might be intrinsic, *i.e.*, a flare star. If you have any observations during the period July 3–5 please submit them soon. We should like confirmation of these observations and to determine the nature of the event.

1. Forthcoming events

Although rates are still high during September, the lack of a major shower means that our knowledge of the minor showers and their telescopic properties is poor. One excellent project would be to search for the minor showers without any prior assumptions. Remember because his plotting accuracy is far superior to the naked-eye watcher, the telescopic observer can identify and pinpoint shower activity that is several times weaker than the sporadic noise.

The observing technique is to select pairs of fields separated by 30°–40° and at elevations of 40°–60°—for most observers that would correspond to $\delta = +10°$—and alternate between them. As the celestial sphere revolves, select new pairs.

There are several minor showers in the Auriga and Cassiopeia sector. The best known are the *δ-Aurigids* and the *α-Aurigids*. The tail end of the latter can be seen during the first week of September. Well placed this year are the δ-Aurigids during October's New-Moon period. According to visual data from the *Arbeitskreis Meteore (AKM)* and an analysis of Hoffmeister's radiants [1], there is also activity from early September. Michael Nolle made observations in 1990 on September 13-14, 14-15 and 16-17 with a 10 × 70 binocular within three fields. His analysis shows no *concrete* evidence for the δ-Aurigids before the accepted activity period. There were seven meteors passing through the predicted radiant at $\alpha = 66°$ and $\delta = +51°$, but six were from a field only a few degrees away from the radiant. During the same watches, however, another radiant is certainly evident at $\alpha = 43°$ and $\delta = +49°$. It was strongest on September 16-17 from when one third of the meteors recorded emanated from it. Michael would like more data for both showers in 1991.

In 1988, I identified a shower of fast and faint meteors (typically of magnitude +10) radiating from a compact region in the "W" of Cassiopeia during late August to mid-September. Peak rates were half the sporadic background. It was also possible to follow the diurnal motion. The radiant moved from midway between α and β Cassiopeiae on September 6-7 to $\alpha = 15°$ and $\delta = +59°$ by September 11-12. In 1989, few of these β-Cassiopeids were recorded. I would very much like confirmatory observations. Observers with telescopes or large binoculars are particularly encouraged to make watches.

A further four meteors seen in all three of Michael Nolle's fields intersect within a few arc minutes at $\alpha = 24.^{\circ}5$ and $\delta = +49.^{\circ}3$. It would be premature to say there was another shower present, however it merits further study.

I bring this to the observers' attention so they can select field centers allowing simultaneous investigation of all four potential radiants. Given the L-shaped geometry, it is impossible to have ideal centers. At least three fields are required, for example: $\alpha = 52°$ and $\delta = +60°$, $\alpha = 43°$ and $\delta = +39°$, and $\alpha = 23°$ and $\delta = +41°$. Before around 23^{h} local time, it may be necessary to select fields at a higher elevation, *e.g.*, $\alpha = 348°$ and $\delta = +74.^{\circ}5$. To conclude, you can see that September holds many surprises and its skies are well worth scrutiny.

The *Piscids* are also rich in faint meteors, yet I have seen little evidence of their telescopic activity possibly due to a diffuse radiant compounded by low hourly rates. Though the sparseness of data could well be the main factor. Their slow velocity ought to make them easier to observe telescopically.

The *Draconids* are enigmatic—capable of storm activity, yet often have disappointed when high rates have been predicted, especially in 1972—usually rates are low. This does not mean that this shower is only worthy of our attention when the parent comet P/Giacobini-Zinner is near perihelion and high rates are possible. The Draconid shower is young and we have an opportunity to watch its development into a mature stream. If the models of stream evolution are correct, we would expect a gradual dispersal of the meteoroids around the stream orbit. This can be detected via monitoring each year. The smallest particles disperse quickest due to Poynting-Robertson and Yarkovsky-Radzievskii effects, and since the Draconids are rich in faint meteors, it is especially important to make telescopic watches to look for activity.

On October 4-5, 1989 *BAA* member Norman Kiernan suspected a radiant from $\alpha = 122°$ and $\delta = +39°$ but only based on five meteors. I would like to know whether this is a true shower.

Reference

[1] J. Rendtel, "Radiants in the Per-Aur Region between August and October", *1990 IMC Proceedings*, Violau, 1990, pp. 37–41.

Another Possibility for Activity from 1990 MF

Dirk Artoos

For the second time this year, the asteroid 1990 MF is crossing the Earth's orbit (see also [1,2]). This time, the shortest distance (0.018 AU) is shorter than in July (0.032 AU). It is a pity for the visual observers that activity is during daylight hours. We wish the radio observers good luck! The observability function for the September approach is shown in Table 1.

Table 1 – Observability function for a four-element antenna elevated at 45° for each hour of the day (local time), four cardinal directions and four latitudes. For the calculations a transmitter distance of 1000 km and a transmitter power of 30 kW were assumed.

Lat.	Dir.	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
+50	S	0	0	0	0	0	0	0	0	0	5	35	64	89	100	94	98	95	75	47	16	0	0	0	0
+50	W	0	0	0	0	0	0	0	0	0	9	57	85	91	98	100	99	94	85	66	30	0	0	0	0
+50	N	0	0	0	0	0	0	0	0	0	4	32	58	88	100	95	100	94	74	42	15	0	0	0	0
+50	E	0	0	0	0	0	0	0	0	0	9	55	80	91	97	100	99	94	92	69	31	0	0	0	0
+35	S	0	0	0	0	0	0	0	0	0	16	53	84	100	90	70	81	100	93	66	31	0	0	0	0
+35	W	0	0	0	0	0	0	0	0	0	25	69	93	96	100	100	97	94	88	76	46	0	0	0	0
+35	N	0	0	0	0	0	0	0	0	0	13	42	67	93	100	94	99	97	75	52	24	0	0	0	0
+35	E	0	0	0	0	0	0	0	0	0	25	68	85	92	96	99	100	98	98	79	45	0	0	0	0
00	S	0	0	0	0	0	0	0	0	0	33	70	95	100	71	0	44	94	99	81	48	8	0	0	0
00	W	0	0	0	0	0	0	0	0	0	44	77	94	100	94	33	14	29	57	74	61	11	0	0	0
00	N	0	0	0	0	0	0	0	0	0	33	68	97	100	84	76	70	97	97	79	47	7	0	0	0
00	E	0	0	0	0	0	0	0	0	0	46	74	66	38	20	17	85	100	98	85	60	11	0	0	0
−35	S	0	0	0	0	0	0	0	0	5	34	60	78	88	100	94	98	88	83	67	44	16	0	0	0
−35	W	0	0	0	0	0	0	0	0	9	47	75	92	100	87	82	74	69	70	74	61	26	0	0	0
−35	N	0	0	0	0	0	0	0	0	6	42	74	96	100	70	23	48	92	100	83	54	20	0	0	0
−35	E	0	0	0	0	0	0	0	0	8	51	71	71	67	71	78	84	100	94	82	57	25	0	0	0

References

[1] C. Steyaert, "New Earth-Grazing Asteroids", *WGN* 18:5, October 1990, p. 186.

[2] D. Artoos, "Possible Activity from 1990 MF?", *WGN* 19:3, June 1991, p. 86.

The Daylight Sextantids

Dirk Artoos

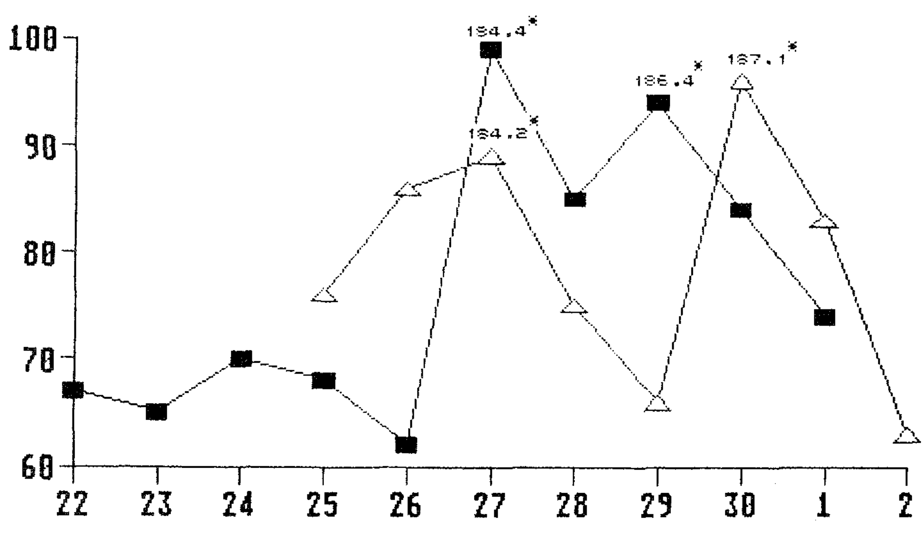

Figure 1 – Number of reflections recorded by the author during end September and begin October in 1989 (squares) and 1990 (triangles), each time between 9^h45^m and 10^h15^m UT. The author listened at 66.45 MHz with an antenna azimuth of 275° and elevation of 40°. Solar longitudes (*) are for eq. 2000.0.

Between September 24 and October 5 we can detect with radio equipment the activity of the Sextantid daylight shower, having its radiant at $\alpha = 152°$ and $\delta = 0°$.

For the second year in a row, I have obtained good results in 1990 from radio observations of this radiant. Also Norihito Kawamura (Japan) has reported a higher hourly rate during the last week of September, more precisely from September 27 to 30 around 3^h–4^h UT, which seems to agree very well with his observation circumstances.

Personally, I had a significantly higher number of reflections on September 27 and 30 (see Figure 1), around 10^h UT. Two remarks have to be made about Figure 1 that also contains observations of 1989. First, it is noteworthy that there are two peaks in both years. Second, there is a remarkable drop in between the peaks on September 29, 1990; this could be caused by atmospheric interferences or something yet unknown.

As a guide for your observations, the observability function is displayed in Table 1.

Table 1 – Observability function for a four-element antenna elevated at 45° for each hour of the day (local time), four cardinal directions and four latitudes. For the calculations a transmitter distance of 1000 km and a transmitter power of 30 kW were assumed.

Lat.	Dir.	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
+50	S	0	0	0	0	7	37	65	89	100	96	92	99	96	77	51	22	0	0	0	0	0	0	0	0
+50	W	0	0	0	0	11	59	86	100	96	99	98	96	90	84	71	35	0	0	0	0	0	0	0	0
+50	N	0	0	0	0	6	29	52	73	96	100	97	99	89	62	41	16	0	0	0	0	0	0	0	0
+50	E	0	0	0	0	10	58	81	89	94	98	100	99	95	94	75	38	0	0	0	0	0	0	0	0
+35	S	0	0	0	0	10	46	77	97	94	59	47	81	100	89	61	27	0	0	0	0	0	0	0	0
+35	W	0	0	0	0	12	59	85	100	95	94	91	87	83	81	73	37	0	0	0	0	0	0	0	0
+35	N	0	0	0	0	8	36	61	79	99	98	95	100	85	71	48	21	0	0	0	0	0	0	0	0
+35	E	0	0	0	0	12	58	77	79	82	86	90	92	100	89	70	34	0	0	0	0	0	0	0	0
00	S	0	0	0	0	10	51	84	100	94	46	0	78	100	94	68	31	0	0	0	0	0	0	0	0
00	W	0	0	0	0	14	62	87	100	98	88	0	5	40	73	86	49	0	0	0	0	0	0	0	0
00	N	0	0	0	0	10	51	84	100	93	45	0	77	100	94	68	31	0	0	0	0	0	0	0	0
00	E	0	0	0	0	29	74	78	50	11	0	0	100	99	98	70	39	0	0	0	0	0	0	0	0
−35	S	0	0	0	0	8	36	61	79	99	98	95	100	85	71	48	21	0	0	0	0	0	0	0	0
−35	W	0	0	0	0	11	59	85	100	95	94	91	87	83	81	73	37	0	0	0	0	0	0	0	0
−35	N	0	0	0	0	9	45	77	99	100	66	44	68	89	81	57	25	0	0	0	0	0	0	0	0
−35	E	0	0	0	0	12	58	77	79	82	86	90	92	100	89	70	34	0	0	0	0	0	0	0	0

Suspected Radiant in Mid-September

Dirk Artoos

As mentioned in [1] and [2], a meteor shower could be active during the morning hours, having a radiant located somewhere in the Orion-Gemini region.

During my observations in 1989, I had more success than in 1990, when I did not register signs of an increased activity (see Figure 1). I cannot find an explanation for this negative result. Nevertheless, Norihito Kawamura mentions a high increase (doubling of the number of the reflections) around September 18, 1990, between 18^h and 20^h UT. This is in good agreement with the observability graphic of this possible radiant with theoretical coordinates $\alpha = 95°$ and $\delta = 12°$. When you are observing visually during that period, please pay attention to this region.

References

[1] D. Artoos, "A Call for Action: September 16", *WGN* 17:4, August 1989, pp. 120–121.

[2] D. Artoos, "Possible Radio Activity in September 1990", *WGN* 18:4, August 1990, pp. 101–102.

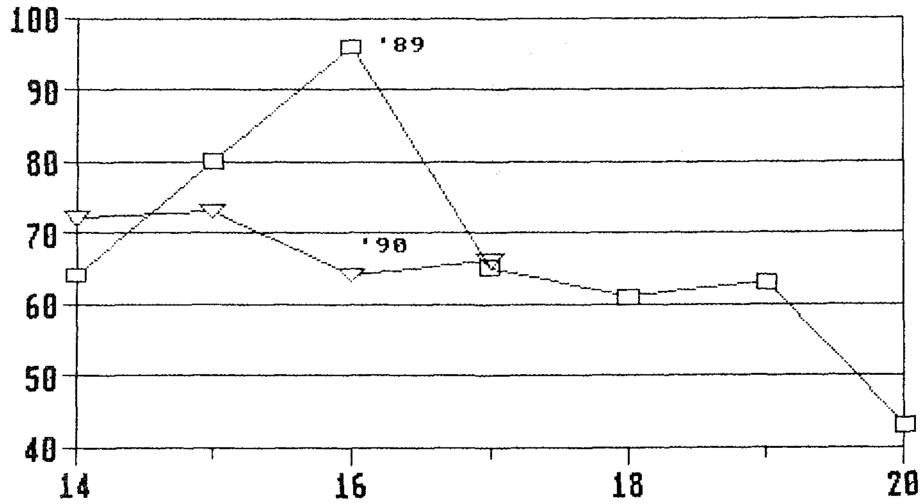

Figure 1 – Number of reflections recorded by the author during mid-September in 1989 (squares) and 1990 (triangles). Observations in 1989 were carried out between 8^h30^m and 9^h10^m UT, observations in 1990 between 8^h45^m and 9^h20^m UT.

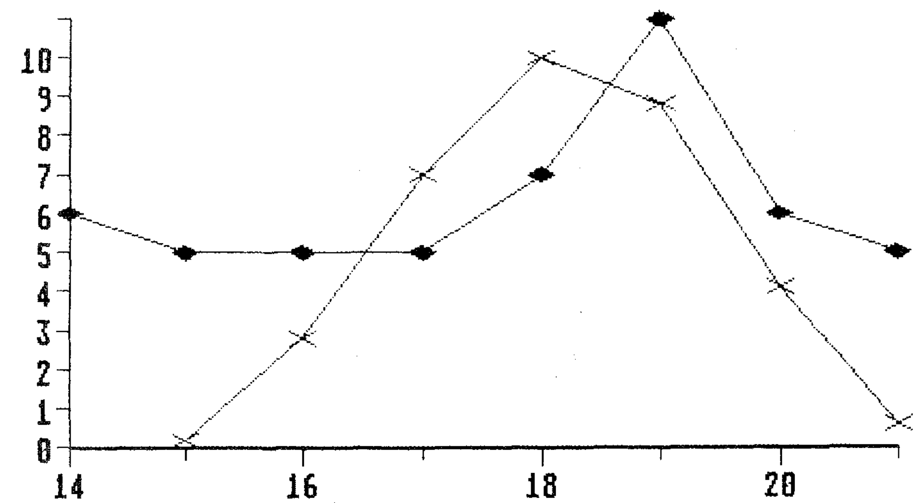

Figure 2 – Hourly rates recorded by Norihito Kawamura on September 18, 1990 between 14^h and 20^h UT (diamonds). As a comparison, the observability function for Japan of the suspected radiant is also given (%/10) (crosses).

The 1992 IMO Meteor Calendar

Marc Gyssens

Thanks to the efforts of *IMO*'s Vice-President, Mr. Alastair McBeath, the 1992 edition of the *IMO* Meteor Calendar has appeared in due time this year. It is forwarded to all *IMO* members, together with this issue and will also be send to several astronomical magazines as a reliable source for data on the observability of meteor streams.

Needless to say, the contents of this *IMO* publication is intended to be *used*. Therefore, local, regional and national groups of meteor amateurs are allowed to copy material from this booklet for their periodicals and newsletters, provided proper credit is given to its source.

We hope that this Calendar will inspire amateurs as well as amateurs-to-be to engage themselves in the fascinating study of meteor phenomena!

The 1990 Orionids

Ralf Koschack and Paul Roggemans

An analysis on the 1990 Orionid data collected by the *International Meteor Organization* shows two distinct maxima. The first maximum occurs at $\lambda_\odot = 207^\circ.35$ and consists mainly of small particles. The second peak at $\lambda_\odot = 209^\circ.7$ is caused by larger particles and is followed by a plateau in the activity profile over $\lambda_\odot = 210^\circ.5$–$213^\circ.5$. (Eq. 2000.0.) The analysis was conducted on 640 effective hours of observations by 111 persons between October 10 and 31. In total 11 824 meteors were reported, 3054 of which were Orionids.

1. Introduction

Since the famous comet P/Halley returned to the outer regions of our Solar System, the *International Halley Watch (IHW)* has been closed down and forgotten by many. However, studies over a long term need much more regular efforts; the *IMO* provides an ideal framework to conduct such future projects. The Orionids were one of the highlights for the *IMO* in 1990. Despite several observing teams at strategic locations being hampered by poor weather, *IMO* was successful in producing one of the best analyses on visual Orionid data ever presented. We are grateful to the following observers who contributed with their visual observing reports. Between brackets, the *IMO* code of the observer is given, followed by the number of meteors seen and the effective observing time.

K. Aiba (AIBKI, 24, $0^h.93$), Javier Alonso (ALOJA, 16, $2^h.23$), S. Anazawa (ANZSE, 22, $1^h.94$), Rainer Arlt (ARLRA, 581, $28^h.11$), Luis Bellot (BELLU, 42, $4^h.58$), Paul Bensing (BENPA, 9, $2^h.80$), Ragnar Bödefeld (BODRA, 212, $8^h.52$), Beata Cabakova (CABBE, 6, $1^h.00$), José Antonio Caceres (CACJO, 29, $2^h.00$), Francisco Campos (CAMFR, 11, $1^h.72$), Mark Davis (DAVMA, 46, $4^h.50$), Albert De Clerck (DE AL, 9, $1^h.58$), Werner Depoorter (DEPWE, 6, $1^h.58$), Roland Egger (EGGRO, 89, $7^h.59$), Phyllis Eide (EIDPH, 80, $9^h.17$), Jan Fabricius (FABJA, 32, $3^h.87$), Yasunori Fujiwara (FUJYA, 25, $1^h.93$), Kai Gaarder (GAAKA, 169, $5^h.91$), George Gliba (GLIGE, 31, $3^h.00$), Daniel Glomski (GLODA, 35, $2^h.08$), Victor Gonzalez (GONVI, 39, $2^h.30$), Robert Haas (HAARO, 179, $13^h.16$), Gabi Haderer (HADGA, 159, $11^h.70$), T. Hasegawa (HASET, 37, $3^h.45$), Takema Hashimoto (HASTA, 40, $4^h.84$), Craig Hinton (HINCR, 178, $8^h.29$), Daiyu Ito (ITODA, 35, $1^h.75$), K. Iwaki (IWAKU, 23, $1^h.94$), Kiyoshi Izumi (IZUKI, 49, $3^h.02$), Toshio Kamimura (KAMTO, 12, $2^h.15$), Stanislav Kaniansky (KANST, 55, $4^h.00$), Norihito Kawamuro (KAWNO, 45, $3^h.85$), Mark Kidger (KIDMA, 43, $2^h.60$), Y. Kikoku (KIKYU, 10, $1^h.64$), André Knöfel (KNOAN, 218, $17^h.06$), Bernhard Koch (KOCBE, 34, $2^h.27$), Detlef Koschny (KOSDE, 164, $8^h.00$), N. Kosiyama (KOSNO, 16, $1^h.28$), Ralf Koschack (KOSRA, 1566, $32^h.07$), Andreas Krawietz (KRAAN, 35, $2^h.08$), Ralf Kuschnik (KUSRA, 33, $2^h.32$), Robert Lunsford (LUNRO, 269, $12^h.54$), Kouji Maeda (MAEKO, 38, $1^h.00$), Katsuhiko Mameta (MAMKA, 186, $11^h.50$), Adam Marsch (MARAD, 20, $1^h.89$), T. Maruyama (MARTA, 18, $0^h.87$), Alastair McBeath (MCBAL, 4, $0^h.58$), Adam Miller (MILAD, 169, $8^h.10$), Anderson Miller (MILAN, 9, $0^h.93$), Koen Miskotte (MISKO, 396, $22^h.41$), H. Mizoguchi (MIZHI, 141, $6^h.14$), Michael Morrow (MORMI, 66, $6^h.92$), K. Murata (MURKE, 17, $1^h.95$), K. Nakasima (NAKKO, 25, $2^h.33$), T. Nakata (NAKTO, 28, $1^h.92$), K. Noze (NOSKU, 57, $6^h.14$), Daniel Ocenas (OCEDA, 23, $3^h.00$), T. Ono (ONOTA, 15, $1^h.96$), Y. Oyama (OYAYO, 70, $2^h.33$), Dulce Plasencia (PLADU, 41, $3^h.69$), Robert Purvinskis (PURRO, 7, $1^h.80$), Leo Rajala (RAJLE, 319, $11^h.70$), Thomas Rattei (RATTH, 35, $2^h.42$), Ina Rendtel (RENIN, 1113, $39^h.54$), Jürgen Rendtel (RENJU, 728, $36^h.56$), Francisco Reyes Andres (REYFR, 21, $3^h.93$), Janko Richter (RICJA, 13, $1^h.31$), James Richardson (RICJM, 20, $2^h.50$), Bauke Rispens (RISBA, 177, $10^h.18$), Pablo Rodriguez (RODPA, 48, $3^h.36$), Paul Roggemans (ROGPA, 767, $39^h.54$), Toru Sagayama (SAGTO, 15, $0^h.87$), Kotaro Sakuma (SAKKO, 16, $2^h.27$), Domingo Salazar (SALDO, 19, $2^h.00$), Hiromi Sato (SATHI, 10, $0^h.93$), T. Sato (SATTA, 19, $1^h.93$), Jens Schlosser (SCHJE, 211, $13^h.82$), Patric Scharff (SCHPA, 95, $6^h.08$), Yasuo Shiba (SIBYA, 28, $5^h.34$), Y. Sikoku (SIKYU, 15, $0^h.90$), T. Simoda (SIMTI, 52, $3^h.46$), K. Siotani (SIOKA, 116, $5^h.08$), Juraj Skvarka (SKVJU, 45, $4^h.00$), James Smith (SMIJN, 105, $5^h.31$), Detlef Spötter (SPODE, 228, $17^h.84$), Siegfried Stapf (STASI, 42, $3^h.75$), Y. Suzuki (SUZMA, 15, $0^h.90$), David Swann (SWADA, 78, $4^h.00$), M. Tada (TADMA, 31, $2^h.91$), Richard Taibi (TAIRI, 64, $9^h.20$), K. Takeuti (TAKKE, 25, $1^h.42$), M. Takanasi (TAKMA, 15, $0^h.88$), M. Takanasi (TAKMI, 19, $0^h.88$), S. Tanaka (TANSY, 22, $0^h.93$), Hiroyuki Tomioka (TOMHI, 26, $3^h.31$), Y. Toriyama (TORYA, 94, $5^h.27$), José Trigo Rodriguez (TRIJO, 13, $1^h.04$), H. Ueda (UEDHI, 16, $1^h.40$), Masayoshi Ueda (UEDMA, 30, $1^h.91$), S. Uehara (UEHSA, 43, $4^h.96$), Toshihiko Ueno (UENTO, 37, $3^h.00$), Cis Verbeeck (VERCI, 5, $1^h.58$), Daniel Verde (VERDA, 68, $4^h.83$), Roger Vodicka (VODRO, 12, $0^h.93$), Roland Winkler (WINRO, 116, $8^h.15$), Tracy Lynn Wit (WITTR, 48, $2^h.00$), Jeff Wood (WOOJE, 338, $14^h.10$), Zhou Xingming (XINZH, 253, $9^h.58$), Yasuo Yabu (YABYA, 16, $2^h.93$), S. Yanagi (YANSI, 117, $2^h.76$), Peter Zimnikoval (ZIMPE, 23, $4^h.00$).

Some more statistical information is available from the *Visual Meteor Database (VMDB)*. The period under investigation runs from October 10 to 31. The 111 observers listed above are grouped per country in Table 1. From the 11 824 meteors seen, only 3054 were Orionids. Other radiants were also covered during the Orionid watch and their totals are listed in Table 2.

Table 1 – Total numbers of observers and meteors and total effective observing time per country.

Country	Observers	Meteors	$T_{\rm eff}$
Germany	18	5461	$235^{\rm h}\!.37$
Japan	44	1710	$119^{\rm h}\!.10$
Australia	8	944	$49^{\rm h}\!.86$
France	1	767	$39^{\rm h}\!.54$
the Netherlands	4	761	$48^{\rm h}\!.55$
United States	10	737	$55^{\rm h}\!.91$
Spain	12	390	$34^{\rm h}\!.28$
Finland	1	319	$11^{\rm h}\!.70$
China	1	253	$9^{\rm h}\!.58$
Czechoslovakia	6	184	$19^{\rm h}\!.87$
Norway	1	169	$5^{\rm h}\!.91$
Canada	1	105	$5^{\rm h}\!.31$
Belgium	3	20	$4^{\rm h}\!.74$
United Kingdom	1	4	$0^{\rm h}\!.58$
Total	111	11824	$640^{\rm h}\!.30$

Table 2 – Total number of meteors observed per shower.

Shower	N	Shower	N	Shower	N
δ-Aurigids (DAU)	10	Capricornids (Oct) (OCC)	8	Taurids South (STA)	611
ε-Geminids (EGE)	262	Orionids (ORI)	3054	Taurids (TAU)	258
Piscids North (NPI)	7	σ-Orionids (SOR)	28	Other showers (DIV)	527
Taurids North (NTA)	531	Piscids South (SPI)	8	Sporadics (SPO)	6520

The Visual Commission of *IMO* thanks the observers for their effort that made this analysis possible. The impressive numbers in Tables 1 and 2 show once again the usefulness of global data collection in the *VMDB*.

2. The population index

The population index r was calculated from individual cumulative magnitude distributions $\Phi(m)$ by linear regression $\log \Phi(m) = m \log r + b$ according to [1,2]. The criteria for including a magnitude distribution in the analysis were set as follows:

a) the faintest magnitude class used had to be brighter than $\mathrm{lm} - 1.3$;
b) from the faintest class onwards there had to be at least five consecutive classes containing at least three meteors each;
c) the total number of shower meteors had to be greater than 25;
d) no $\Phi(m)$ differs by more than 40
e) the correlation coefficient is higher than 0.98.

If more than five classes fulfilled the criteria, the regression was carried out for all possible intervals and the regression having the highest correlation coefficient was taken as the most reliable result. Magnitude distributions not fulfilling the criteria *a–c* were cumulated per date interval until the resulting magnitude distribution fulfilled these criteria. In this way, reliable individual population indices were obtained. The individual values were then averaged per date interval (centered at $0^{\rm h}$ UT from $12^{\rm h}$ UT to $12^{\rm h}$ UT).

The resulting profile for the Orionids is shown in Figure 1 (left) and Table 3. For comparison, the corresponding profile for the sporadics is shown in Figure 1 (right) and Table 4. The error bars given in Figure 1 and in Tables 3 and 4 correspond to the 68% confidence interval $\sigma/\sqrt{n}$ with n the number of individual values. For $n = 1$, σ was obtained according to the results of the simulations in [1] using the approximation given in [2]:

$$\sigma = 4.07\,N^{-0.764} + 0.2$$

with N the number of shower meteors.

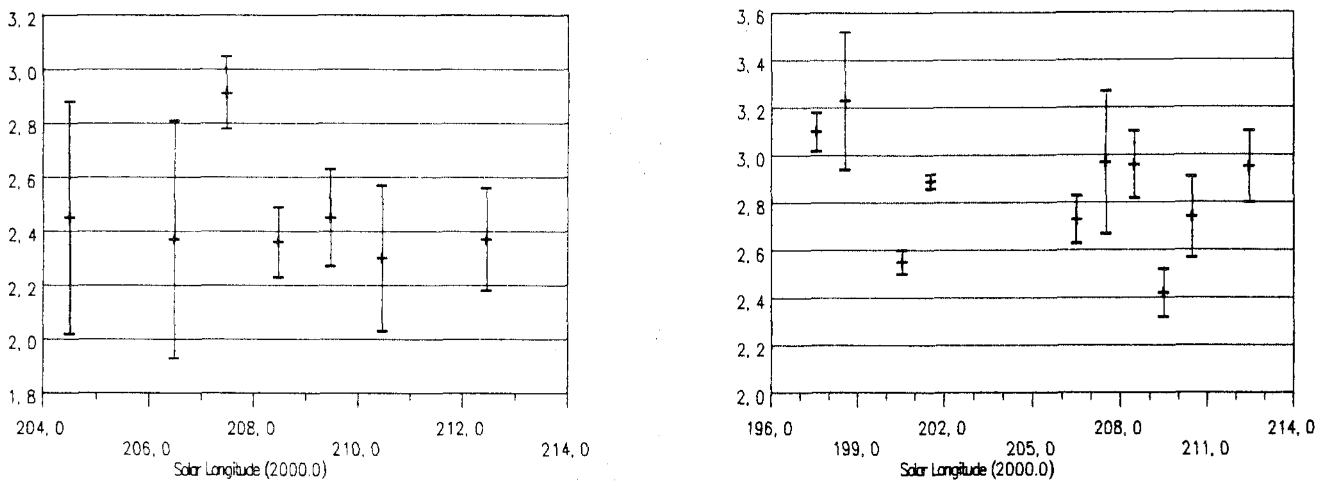

Figure 1 – Profile of the population index r for the 1990 Orionids *(left)* and for the sporadics in October 1990 *(right)*.

Table 3 – The r-profile for the 1990 Orionids.

Date	$\lambda_\odot$ (2000.0)	r-values	Meteors	$\overline{\text{lm}}$	r
Oct 18	204°50	1	43	6.87	2.45 ± 0.43
Oct 20	206°48	1	40	6.60	2.37 ± 0.44
Oct 21	207°48	5	394	6.69	2.91 ± 0.14
Oct 22	208°47	7	326	6.67	2.36 ± 0.13
Oct 23	209°47	5	277	6.21	2.45 ± 0.18
Oct 24	210°46	3	123	6.40	2.30 ± 0.27
Oct 26	212°45	3	104	6.71	2.37 ± 0.19

Table 4 – The r-profile for the sporadic meteors in October 1990

Date	$\lambda_\odot$ (2000.0)	r-values	Meteors	$\overline{\text{lm}}$	r
Oct 11	197°56	2	159	6.71	3.10 ± 0.08
Oct 12	198°55	1	146	6.74	3.23 ± 0.29
Oct 14	200°53	2	102	6.87	2.55 ± 0.05
Oct 15	201°52	2	171	6.97	2.89 ± 0.03
Oct 20	206°48	2	96	5.56	2.73 ± 0.10
Oct 21	207°48	3	476	6.97	2.97 ± 0.30
Oct 22	208°47	7	697	6.49	2.96 ± 0.14
Oct 23	209°47	3	136	6.27	2.42 ± 0.10
Oct 24	210°46	2	92	5.73	2.74 ± 0.17
Oct 26	212°45	3	467	6.91	2.95 ± 0.15

For the Orionids, we find a remarkable peak at $\lambda_\odot = 207.^\circ5$ (October 21.0) of $r = 2.91 \pm 0.14$ while the level for the rest of the activity period is $r \approx 2.4$. It is interesting to notice that such sudden increase in r was also reported in 1974 by Hajduk and Šimek [3] when a remarkably high population index for the Orionids was found at $\lambda_\odot = 206.^\circ7$.

One might argue that the peak in the Orionid r-profile is caused by observational effects. To test this, the population index profile was compared with that for the sporadic meteors during the same period, calculated using the same method. The level lies around $r = 2.8$–3.0 without any significant increase on October 21. This rather low level can be due to the relatively high contribution of the apex source in the fall of the northern hemisphere. Anyway, we can safely conclude that the peak in the Orionid r-profile is real.

3. The ZHR profile

In total, 442 ZHRs were calculated with limiting magnitude better than 5.0 and a radiant elevation of at least 15° for the *entire* observing interval. The zenith correction factor was calculated as in [4], correcting for the geometrical conditions only, i.e., the zenith exponent γ was set to 1.

In the next step, perception coefficients (i.e., corrections Δlm for the limiting magnitude) of the individual observers were calculated according to [4,5]. For this purpose the interval $\lambda_\odot = 206.^\circ0$–$214.^\circ0$ was chosen as the activity and the number of ZHRs available permitted this. The sampling interval was 1°, shifted by $0.^\circ25$ each step. Observations fulfilling the following criteria were taken into account:

a) total correction factor less than 3;
b) radiant elevation greater than 25° for the center of the observing interval.

All observing methods and directions were permitted. Table 5 shows the result for the individual observers. Observers not mentioned in this table did not observe in the chosen interval or their observations did not meet the criteria above.

Table 5 – Perception coefficients P and corrections Δlm for the limiting magnitude derived from the 1990 Orionid observations.

Observer	Obs.	P	Δlm	Observer	Obs.	P	Δlm
Arlt Rainer	24	1.05	0.00 ± 0.28	Rajala Leo	8	3.12	$+1.28 \pm 0.22$
Bellot Luis	10	0.46	-0.90 ± 0.46	Rattei Thomas	3	1.31	$+0.30 \pm 0.19$
Bödefeld Ragnar	11	1.00	-0.03 ± 0.24	Rendtel Ina	24	1.10	$+0.06 \pm 0.30$
Davis Mark	4	0.53	-0.70 ± 0.25	Rendtel Jürgen	20	1.37	$+0.34 \pm 0.08$
Egger Roland	7	1.85	$+0.60 \pm 0.49$	Reyes Andres Francisco	7	0.46	-0.87 ± 0.42
Fabricius Jan	4	1.37	$+0.36 \pm 0.02$	Richardson James	4	0.87	-0.15 ± 0.08
Gliba George	4	1.42	$+0.42 \pm 0.10$	Richter Janko	3	0.91	-0.12 ± 0.19
Glomski Daniel	4	1.74	$+0.56 \pm 0.08$	Rispens Bauke	8	1.31	$+0.27 \pm 0.08$
Gonzalez Victor	4	0.23	-1.70 ± 0.00	Rodriguez Pablo	4	0.51	-0.79 ± 0.26
Haas Robert	12	1.21	$+0.18 \pm 0.24$	Roggemans Paul	24	0.99	-0.06 ± 0.28
Haderer Gabi	11	0.63	-0.57 ± 0.29	Salazar Domingo	4	0.19	-1.90 ± 0.25
Kaniansky Stanislav	4	2.45	$+1.04 \pm 0.02$	Scharff Patric	4	0.36	-1.20 ± 0.00
Kawamuro Norihito	4	0.65	-0.43 ± 0.18	Shiba Yasuo	4	0.35	-1.06 ± 0.18
Kidger Mark	4	0.66	-0.50 ± 0.26	Skvarka Juraj	4	1.52	$+0.49 \pm 0.02$
Knöfel André	16	0.28	-1.34 ± 0.14	Spötter Detlef	19	1.69	$+0.54 \pm 0.41$
Koch Bernhard	8	0.75	-0.39 ± 0.42	Stapf Siegfried	3	1.13	$+0.14 \pm 0.03$
Koschack Ralf	24	0.96	-0.06 ± 0.20	Taibi Richard	12	0.58	-0.64 ± 0.34
Koschny Detlef	4	1.15	$+0.15 \pm 0.04$	Takeuti K.	4	1.80	$+0.57 \pm 0.18$
Lunsford Robert	22	0.72	-0.42 ± 0.43	Toriyama Y.	4	2.95	$+1.17 \pm 0.06$
Maeda Kouji	4	2.80	$+0.99 \pm 0.17$	Winkler Roland	4	0.52	-0.77 ± 0.02
Miskotte Koen	20	0.90	-0.16 ± 0.30	Xingming Zhou	7	1.56	$+0.47 \pm 0.39$
Oyama Y.	8	3.50	$+1.22 \pm 0.22$	Zimnikoval Peter	4	0.53	-0.74 ± 0.02

Table 6 – Intervals for the computation of the final ZHR profile and criteria set

$\lambda_\odot$	Width	Shift	h_{min}	C_{max}	D_{max}	Method
200°0–202°5	1°0	0°5	30°	3	50°	plotting
204°5–204°65			20°	3	60°	plotting
206°0–210°0	1°0	0°25	20°	3		all
210°0–215°0	2°0	0°5	20°	3		all

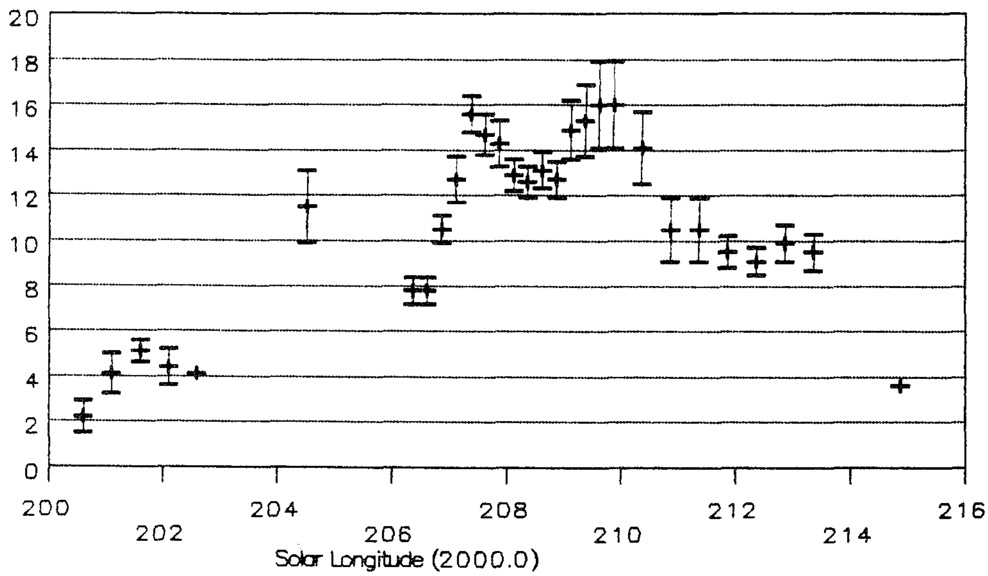

Figure 2 – ZHR profile of the 1990 Orionids

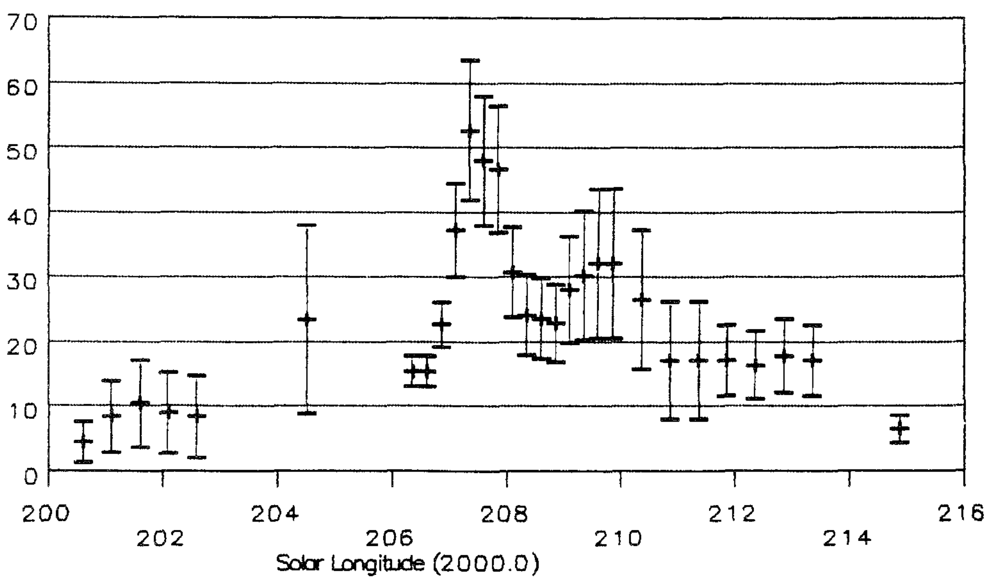

Figure 3 – Profile of the spatial number density $\rho_{6.5}$ of particles causing meteors of absolute magnitude at least +6.5 (corresponding to a mass of at least 3.07×10^{-5} g). On the vertical axis, numbers of particles per 10^9 km^3 are shown.

Then, all ZHRs were perception-corrected with:

$$\mathrm{ZHR_{corr}} = \mathrm{ZHR_{obs}} \times r^{-\Delta \mathrm{lm}}$$

The value of Δlm for observers not listed in Table 5 was set to zero. Finally, the ZHR profile was calculated according to [5]. The intervals chosen are listed in Table 6. For each period are given: the width of the sampling interval and the shift at each step and: the minimum radiant elevation $h_{\min}$; the maximal total correction factor $C_{\max}$; the maximal radiant distance of the observing field $D_{\max}$; and the observing methods allowed.

The intervals were chosen taking into account the available ZHR values. In the begin of the activity the criteria were set like for observations of minor showers as at this activity level the Orionids have to be treated as such.

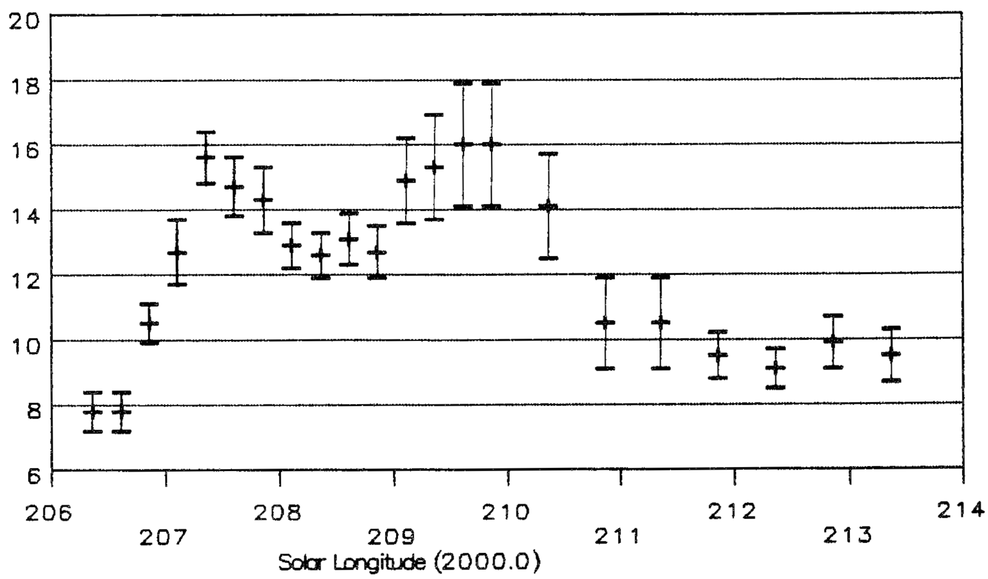

Figure 4 – Detail of Figure 2, around maximum

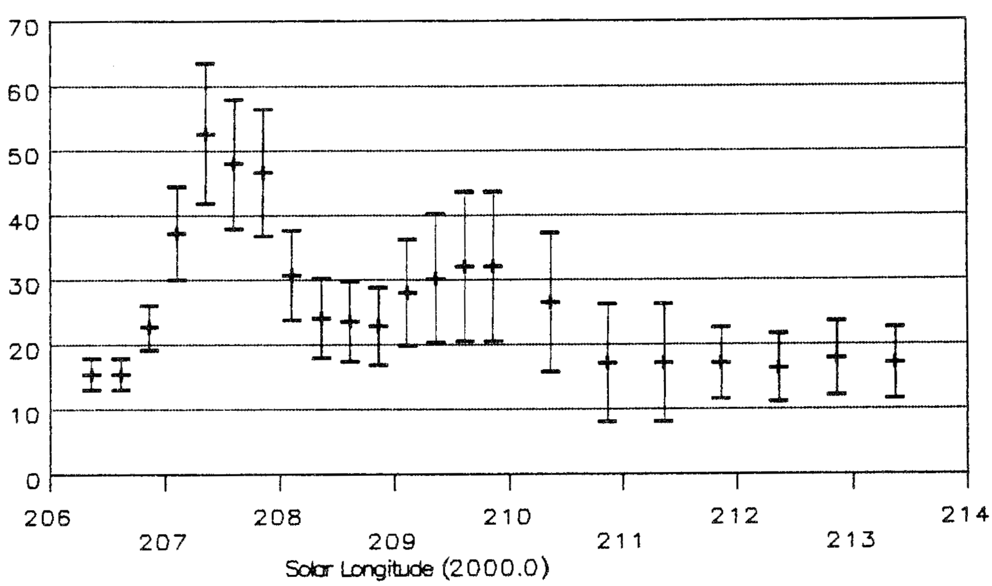

Figure 5 – Detail of Figure 4, around maximum

The result can be seen in Table 7 and in Figures 2 and 4 (Figure 4 is a detail of Figure 2 around the maximum.) The error bars correspond to the 68% confidence interval $\sigma/\sqrt{n}$ with n the number of observations.

A first maximum occurs at $\lambda_\odot = 207\overset{\circ}{.}35$ (Oct 20.88) with a ZHR of 15.6 ± 0.8 followed by a period with a ZHR of approximately 13 from $\lambda_\odot = 208\overset{\circ}{.}0$ to $\lambda_\odot = 209\overset{\circ}{.}0$ (Oct 21.5–22.5). The second maximum occurs at $\lambda_\odot = 209\overset{\circ}{.}7$ (Oct 23.25) with a ZHR of 16.0 ± 1.9. Before the ZHR decreases rapidly, there is a plateau with a ZHR of approximately 10 at $\lambda_\odot = 210\overset{\circ}{.}5$–$213\overset{\circ}{.}5$.

The shape of the first peak and the following period of lower activity is quite reliable as it is based on many observations while the number of observations the second peak is based on is only about a quarter of that [6]. The lower number of observations available was the reason for extending the sampling interval to 2. The existence of the second peak has been confirmed by past observations, as will be discussed later.

4. Spatial number densities

First, we consider the spatial number density $\rho_{6.5}$ of particles causing meteors of absolute magnitude at least +6.5. The calculation was carried out according to [2].

For the calibration the standard observers `ARLRA`, `KOSRA`, `RENIN`, `RENJU` and `ROGPA` were used. `KNOAN` is also a standard observer but his Δlm differs considerably from those of the other standard observers. Therefore, a test for rejection of outliers was applied. It turned out that the factor of `KNOAN` has to be considered as an outlier and thus was not taken into account for the calibration purpose. The average correction of the standard observers is $\Delta lm_{\text{avg}} = +0.056 \pm 0.073$.

The profile of the spatial number density $\rho_{6.5}$ is shown in Table 7 and in Figures 3 and 5 (Figure 5 is a detail of Figure 3 around maximum). In this profile, the first maximum occurring at $\lambda_\odot = 207\overset{\circ}{.}35$ is dominant. It coincides with the striking peak in the population index profile, meaning that the increase is mainly due to smaller particles. Since for fainter meteors a larger part is missed by the human eye, the real peak of the $\rho_{6.5}$ profile is not displayed by the ZHR curve in an adequate way. The second maximum of the ZHR profile is also present in the $\rho_{6.5}$ profile, but not as striking as the first one.

If the initial relation between the particle mass M, the geocentric velocity V_∞, and the meteor magnitude m is known, it is possible to compute number density profiles for particles of different masses. In [2], the following relation, given in [7], was used:

$$m = 40 - 2.5 \log \left(2.732 \times 10^{10} \,.\, M^{0.92} \,.\, V_\infty^{3.91}\right)$$

with M in grams and V_∞ in km/s. Using this relation the spatial number density $\rho(M \geq M_0)$ of particles having masses greater than a certain limit M_0 results from $\rho_{6.5}$ by:

$$\rho(M \geq M_0) = \rho_{6.5} r^{9.775 \log(5.726 M_0^{-0.2353}/V_\infty)}$$

For the Orionids ($V_\infty = 66$ km/s), magnitude +6.5 corresponds to a particle mass M of 3.07×10^{-5} g. To investigate the shape of the number density profile for different mass ranges, $\rho(M \geq M_0)$ was computed for $M_0 = 0.1$ mg (corresponding to magnitude $m = +5.3$), $M_0 = 1$ mg ($m = +3.0$), $M_0 = 5$ mg ($m = +1.4$), and $M_0 = 20$ mg ($m = 0.0$). It is not useful to continue the computations for higher masses as the computation is based on a constant r-value for the magnitude range covered. In this analysis, r was usually computed in the magnitude interval $[-1; +5]$.

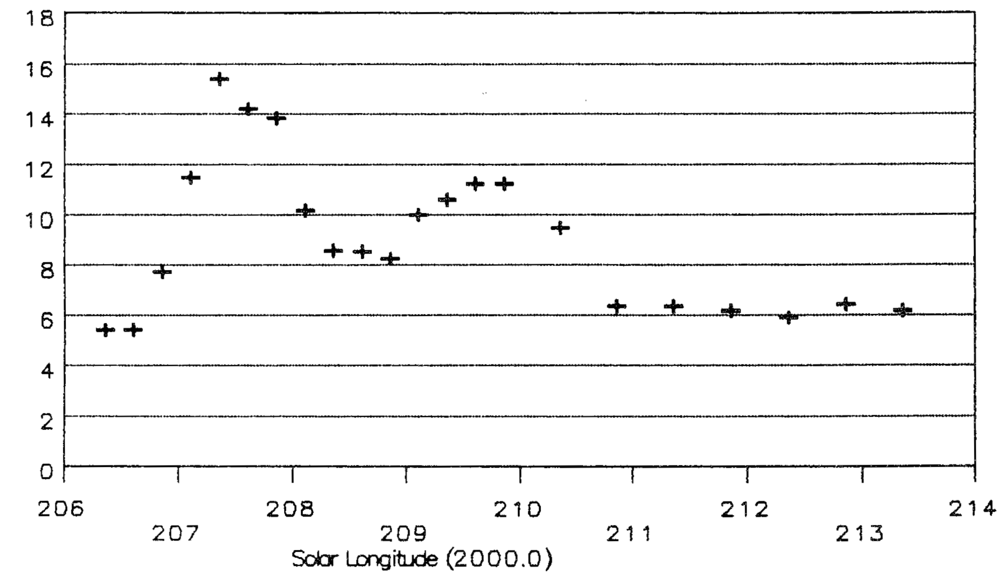

Figure 6 – Profile of the spatial number density $\rho(M \geq 0.1$ mg) of particles having masses of at least 0.1 mg (corresponding to magnitude $m = +5.3$).

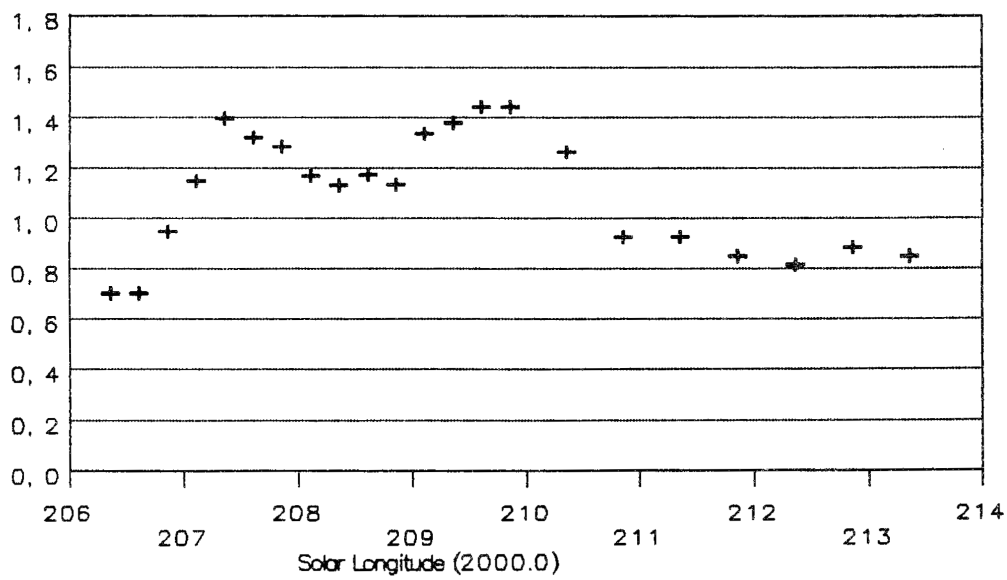

Figure 7 – Profile of the spatial number density $\rho(M \geq 1$ mg) of particles having masses of at least 1 mg (corresponding to magnitude $m = +3.0$).

The resulting profiles are shown in Figures 6 to 9.

It is quite obvious that for the smallest particles, the maximum is reached at $\lambda_\odot = 207\overset{\circ}{.}35$ (corresponding to the first peak in the ZHR profile) while for the larger particles, it is reached at $\lambda_\odot = 209\overset{\circ}{.}7$ (second peak in the ZHR profile). The first peak in the ZHR profile is caused only by small particles, which is indicated by the striking peak in the population index profile at this time. For the brightest meteors ($M_0 = 5$ mg and $M_0 = 20$ mg), the first peak is almost non existent, while in telescopic or radio observations, the second one should not be found.

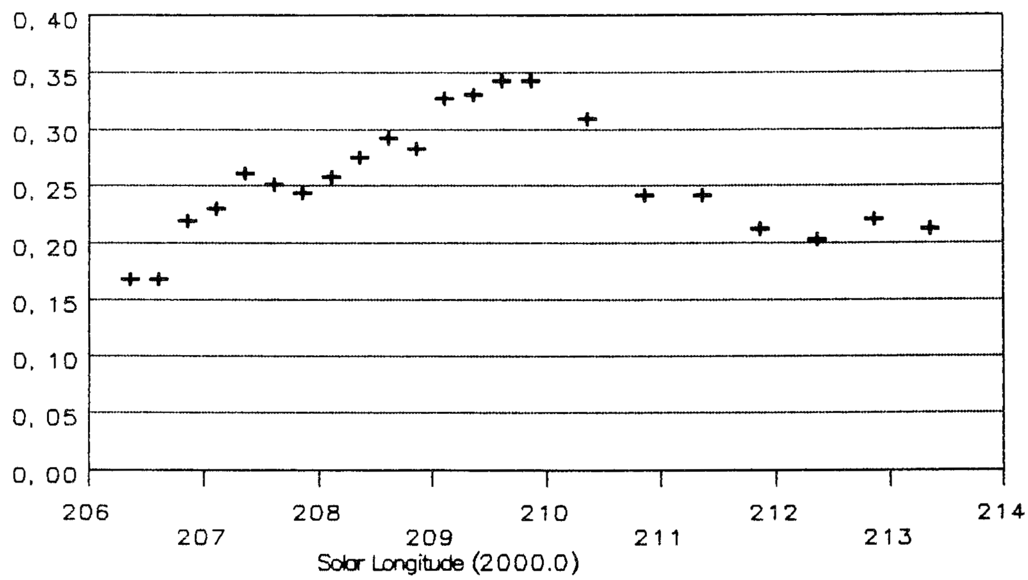

Figure 8 – Profile of the spatial number density $\rho(M \geq 5$ mg$)$ of particles having masses of at least 5 mg (corresponding to magnitude $m = +1.4$).

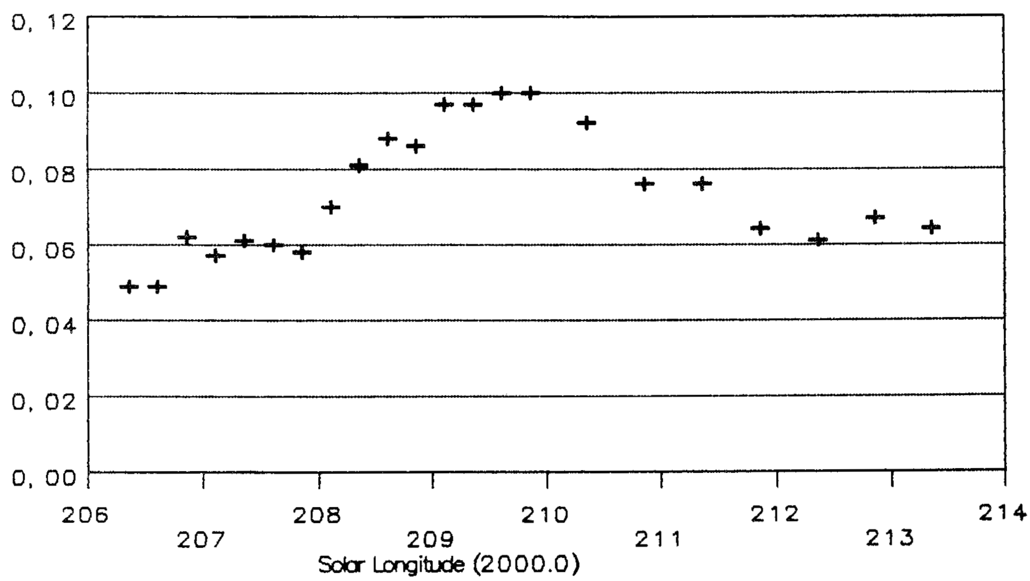

Figure 9 – Profile of the spatial number density $\rho(M \geq 20$ mg$)$ of particles having masses of at least 20 mg (corresponding to magnitude $m = 0.0$).

Of course, the absolute values for $\rho(M \geq M_0)$ depend strongly on the relationship between m, M and V_∞, but the shape of the profiles does not: the shape depends on both the ZHR and the population index profile. To point it out once again: magnitude distributions as basis for the computation of the r-value are at least as important as the ZHR data. The ZHR profile alone does not tell very much; the r profile is the key for investigations like those reported here.

Table 7 – Numeric values for r, ZHR, $\rho_{6.5}$ and $\rho_M = \rho(M > 10^{-3}$ g) for the 1990 Orionids.

Date	$\lambda_\odot$ (2000.0)	r	Obs	Met	ZHR	$\rho_{6.5}$	ρ_M
Oct 14.07	200°60	2.45 ± 0.43	3	12	2.2 ± 0.7	4.5 ± 3.1	0.2
Oct 14.57	201°10	2.45 ± 0.43	8	48	4.1 ± 0.9	8.3 ± 5.5	0.4
Oct 15.08	201°60	2.45 ± 0.43	11	61	5.1 ± 0.5	10.4 ± 6.7	0.5
Oct 15.58	202°10	2.45 ± 0.44	7	28	4.4 ± 0.8	9.0 ± 6.3	0.4
Oct 16.09	202°60	2.45 ± 0.44	1	3	4.1	8.3 ± 6.3	0.4
Oct 18.02	204°51	2.45 ± 0.44	6	100	11.5 ± 1.6	23.4 ± 14.6	1.0
Oct 19.88	206°36	2.43 ± 0.02	18	128	7.8 ± 0.6	15.4 ± 2.4	0.7
Oct 20.13	206°61	2.43 ± 0.02	18	128	7.8 ± 0.6	15.4 ± 2.4	0.7
Oct 20.38	206°86	2.49 ± 0.03	24	208	10.5 ± 0.6	22.7 ± 3.4	0.9
Oct 20.63	207°11	2.72 ± 0.09	26	347	12.7 ± 1.0	37.2 ± 7.2	1.1
Oct 20.88	207°36	2.84 ± 0.13	24	505	15.6 ± 0.8	52.7 ± 10.8	1.4
Oct 21.13	207°61	2.81 ± 0.13	29	560	14.7 ± 0.9	48.0 ± 10.0	1.3
Oct 21.39	207°86	2.81 ± 0.13	24	502	14.3 ± 1.0	46.7 ± 9.9	1.3
Oct 21.63	208°11	2.56 ± 0.13	33	572	12.9 ± 0.7	30.7 ± 7.0	1.2
Oct 21.88	208°36	2.41 ± 0.14	31	508	12.6 ± 0.7	24.1 ± 6.2	1.1
Oct 22.14	208°61	2.37 ± 0.14	29	508	13.1 ± 0.8	23.5 ± 6.2	1.2
Oct 22.38	208°86	2.37 ± 0.14	28	486	12.7 ± 0.8	22.8 ± 6.0	1.1
Oct 22.64	209°11	2.40 ± 0.16	18	356	14.9 ± 1.3	28.1 ± 8.2	1.3
Oct 22.89	209°36	2.43 ± 0.18	15	228	15.3 ± 1.6	30.2 ± 10.0	1.4
Oct 23.14	209°61	2.44 ± 0.19	12	173	16.0 ± 1.9	32.1 ± 11.6	1.4
Oct 23.39	209°86	2.44 ± 0.19	12	173	16.0 ± 1.9	32.1 ± 11.6	1.4
Oct 23.89	210°36	2.40 ± 0.21	19	233	14.1 ± 1.6	26.6 ± 10.7	1.3
Oct 24.39	210°86	2.31 ± 0.26	7	60	10.5 ± 1.4	17.1 ± 9.1	0.9
Oct 24.99	211°36	2.31 ± 0.26	7	60	10.5 ± 1.4	17.1 ± 9.1	0.9
Oct 25.40	211°86	2.37 ± 0.19	11	175	9.5 ± 0.7	17.1 ± 5.5	0.8
Oct 25.90	212°36	2.37 ± 0.19	10	155	9.1 ± 0.6	16.4 ± 5.2	0.8
Oct 26.40	212°86	2.37 ± 0.19	11	180	9.9 ± 0.8	17.8 ± 5.8	0.9
Oct 26.90	213°36	2.37 ± 0.19	12	184	9.5 ± 0.8	17.1 ± 5.6	0.8
Oct 28.41	214°86	2.37 ± 0.19	1	4	3.6	6.5 ± 2.1	0.3

5. Comparison with previous research

A literature search with the *Bibliographic Meteor Database* resulted in over one hundred references dealing with the Orionid Meteor Stream. These publications were read and summarized in order to compare our findings with previous results. Unfortunately, many past publications were of no use as the essential data were left out. This was particularly the case for most amateur publications, describing meteor observations rather as a social story, avoiding numeric tables and exact numbers. This reduces the amount of useful past reports to a very small number indeed. At the beginning of the twentieth century, there was even still much doubt as to whether or not the Orionids were associated with comet P/Halley and the η-Aquarids at the other node. In our opinion, it is almost impossible to get a reliable picture on the long-term behavior of the Orionids from amateur work.

While complete observing series covering Orionid activity in the past are missing, some individual reports are very remarkable. For instance, R.M. Dole, probably the most active American meteor observer ever, mentions 50 Orionids an hour on October 21, 1922 [8]. Eppe Loreta, an Italian observer, reported 50 Orionids in one hour on October 22, 1936 [9]. The strong Orionid activity in 1936 was also observed by M. Kahn in India [10]. It is a pity that the few dedicated observers worked in an almost unorganized way in the past.

Searching for comparable analysis to the 1990 study by the *IMO*, we came across only two papers dealing with visual work.

The first paper was produced by Stohl and Porubcan on Slovak observations from the period 1945 to 1950 [11]. Their data contain 956 Orionids and 1830 sporadics seen in 305.6 hours of observing. Taking together data from several years in order to complete the activity profile of the Orionids has serious drawbacks because of the strong variations every year. However, the study of Stohl and Porubcan is the only one on visual data telling us something about the population index. Both authors conclude that r varies from 2.9 at $\lambda_\odot = 206°$–$207°$ to 3.2–3.3 at $\lambda_\odot = 210.5°$. This suggests that the inner edge of the stream would be richer in faint particles, a conclusion that does not agree with the results from the 1990 analysis.

The other paper, the best visual study of the Orionids thus far, was conducted by George Spalding [12], director of the Meteor Section of the British Astronomical Association. From around the world, he collected all usable data on the 1985 Orionids, altogether 555 hours of observation and 10 675 meteors. It was the first study of visual data based on a single year. Unfortunately, no magnitude distributions could be studied as a consequence of which the r-value was assumed to be constant, $r = 2.25$. Furthermore, the quality selection was less strong than in this 1990 study. E.g., the minimum radiant elevation was set at 10°. Spalding found a stable zone of high activity between $\lambda_\odot = 206°$ and $\lambda_\odot = 210°$, with at the center ($\lambda_\odot = 208°$) a dip with no statistical evidence. There was also some indication of a peak at $\lambda_\odot = 203°$.

Some scientists [13] tried to compare professional radar results to individual amateur visual observations. However, this is not very meaningful taking into account the statistical fluctuations and various influences that determine individual results. Global analyses are essential in order to obtain reliable results from amateur observations.

At this point, it becomes clear that the observational evidence for the composition of the Halley streams is far less impressive than what could have been assumed. Most of our current knowledge is based on radar observations, which have some limitations. For instance, the Orionid activity is somewhat contaminated by the ε-Geminids [14]. Radar is not able to distinguish between the two streams. Also, it does not allow to resolve short-lived changes in either the activity level or the population index. Different radar data sets for the same year often yield non-compatible activity profiles [14]. Global activity profiles from visual observers have more weight statistically and allow to reconstruct a much more detailed picture of a stream's cross-section.

Anton Hajduk is the only researcher who made a long term study, including relevant radar data [15]. He found several sub-maxima each year, the particle distribution in each cross section varying significantly, however [13]. Hajduk used rather non-homogeneous sets of visual data as well as more reliable radar observations, but his study nevertheless illustrates very clearly that density variations do not only occur along the stream, but also across the stream. The sub-maxima seem to shift in solar longitude year after year. The density variations can reach an amplitude of 1 : 4 in certain years. Radar monitoring indicated that the Orionid stream contains mainly small particles, producing faint meteors. Only the central belt contains a higher number of larger particles.

It is interesting to compare the positions at which different researchers situated the main belt and the secondary maxima:

- Main maximum at $\lambda_\odot = 208.7°$ and $\lambda_\odot = 210.7°$, but generally very low rates, in 1938 [16];
- Main maximum at $\lambda_\odot = 208.5°$ and secondary maximum at $\lambda_\odot = 210.5°$, from observations in 1945 to 1950 [11,17];
- Maxima at $\lambda_\odot = 202.7°$, $\lambda_\odot = 206.7°$, and $\lambda_\odot = 211.2°$, in 1974 [3];
- Sharp increase between $\lambda_\odot = 208.7°$ and $\lambda_\odot = 209.7°$, secondary maxima at $\lambda_\odot = 207.7°$ and $\lambda_\odot = 210.2°$ with more large particles at 210.7°, in 1975 [18];
- Central peak at $\lambda_\odot = 208.0°$ and $\lambda_\odot = 208.7°$, in 1978 and 1979 [19];
- Maxima at $\lambda_\odot = 204.5°$, $\lambda_\odot = 209.6°$, and $\lambda_\odot = 212.4°$, in 1981 [14];
- Main maximum at $\lambda_\odot = 208.2°$, but the activity profile is defined by only one value every 24 hours, in 1981 [20];

- Maxima at $\lambda_\odot = 205\overset{\circ}{.}0$, $\lambda_\odot = 208\overset{\circ}{.}1$, $\lambda_\odot = 209\overset{\circ}{.}9$, and $\lambda_\odot = 211\overset{\circ}{.}5$, with generally above average activity, in 1982 [14];
- Maximum at $\lambda_\odot = 214\overset{\circ}{.}0$, but poor overall activity, in 1983 [14];
- Main maximum at $\lambda_\odot = 209^\circ$, in 1984 [13];
- Maxima at $\lambda_\odot = 206\overset{\circ}{.}6$, $\lambda_\odot = 208\overset{\circ}{.}5$, $\lambda_\odot = 210\overset{\circ}{.}4$, and $\lambda_\odot = 214\overset{\circ}{.}5$, in 1984 [14];
- Three maxima at $\lambda_\odot = 203\overset{\circ}{.}7$, $\lambda_\odot = 208\overset{\circ}{.}7$, and $\lambda_\odot = 212\overset{\circ}{.}7$, in 1985 [21];
- Maxima at $\lambda_\odot = 203\overset{\circ}{.}5$, $\lambda_\odot = 204\overset{\circ}{.}5$, $\lambda_\odot = 208\overset{\circ}{.}5$, $\lambda_\odot = 209\overset{\circ}{.}6$, and $\lambda_\odot = 211\overset{\circ}{.}4$, in 1985 [14].

From the positions of the main maxima in successive years, Cevolani and Hajduk conclude that the maxima shift by $\Delta\lambda_\odot = 0\overset{\circ}{.}6$ per year. Also Hughes [22] found certain sequences of years that show a regular progression in the movement of the position of maximum activity.

The overall picture of the Orionid Meteor Stream may look very confusing with the activity profiles differing in all aspects from one year to another. Hajduk [15] developed a theory which explains the observed facts very well. We sketched the image of the Halley meteor streams in Figure 10. The figure is not on scale in order to bring together different elements into one picture.

We all know that meteoroids exist in orbits their parent comet was in many revolutions ago. The orbit of P/Halley librates arounds its semi-major axis over an angle of 25°. Each libration cycle takes a few hundreds of revolutions, creating a ribbon-shaped belt of meteoroid particles which are confined to a strip extending over an angle of 25°, seen from the major axis. The libration cycles of comet P/Halley were determined by Kozai [23].

Since also the direction of the semi-major axis slowly changes, the positions of the orbits of P/Halley in a new libration cycle will not coincide with the corresponding positions in a previous cycle. In this way, successive ribbon-like dust walls are built up, almost parallel to each other, all perpendicular to the orbital plane of the comet. Intersection D in Figure 10 shows the cross section of the whole stream according to Hajduk's theory. The width of this cross section (measured in the ecliptic plane) would be some 0.044 AU, whereas its height (measured perpendicularly to the ecliptic plane) would be about ten times larger. Some belts are older than others and must therefore contain fewer small particles.

At this point, the multiple maxima and the variations in population index can already be explained. The lack of a regular pattern and the strong variations year after year however need a more refined explanation.

Looking at the inset C in Figure 10, we see that in successive years, different sub-maxima occur, although some appear in only slightly shifted positions in solar longitude. Looking at the longitudinal structure of the Halley meteor stream (shown in Figure 10, detail C), the sub-maxima are caused by the passage of the Earth through filaments along the stream orbit. However, the orientation of these filaments varies as is shown in Figure 10, C, where the filaments are visualized as the black nerve-like patterns. The contrast is much exaggerated; the particle densities within and in between the filaments have a ratio of only 1 : 2 or even less. Exceptionally high activity in some years may simply be attributed to two filaments meeting or crossing each other [15].

It should be noted that the beginning of a condensation zone or filament shows an increased abundance of small particles. This suggests that the filamentary structure can be explained by temporary ejections of particles from the comet, producing a wave front of fresh particles that gradually dissolves in the stream [24]. The observed large number of smaller particles at the beginning of a new filament then agrees with Whipple's and Levin's concept of larger initial velocities for the smaller particles that leave the comet [25]. The filamentary structure was also measured and within the observational errors confirmed by the ESA space probe Giotto [23,26], which provided additional explanation from the dust emission process and the fact that only a small area of the surface of the comet nucleus is active.

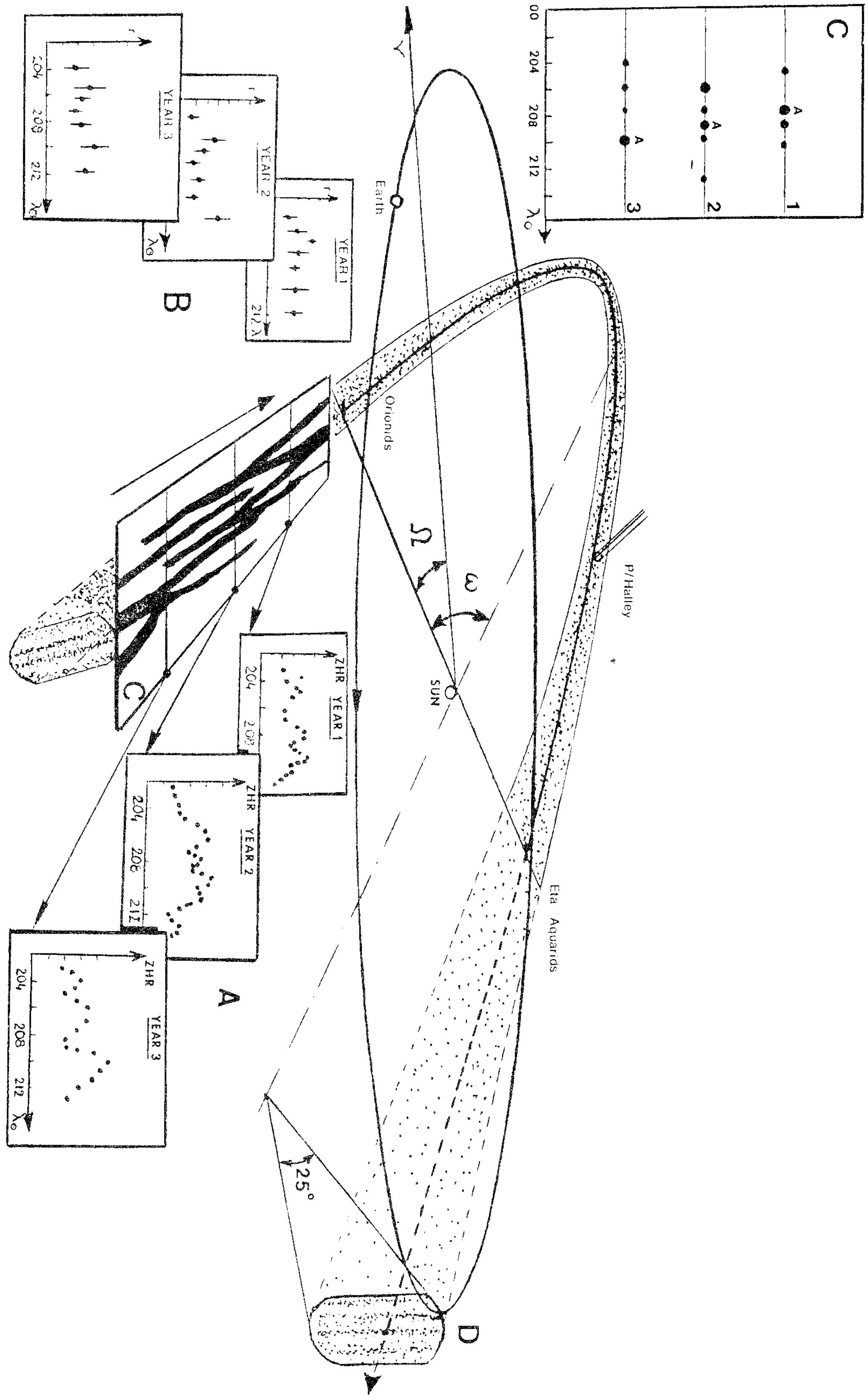

Figure 10 –Sketch illustrating the structure of the Orionids and η-Aquarids, the comet P/Halley meteor streams. The various features of this sketch are explained in the text. The population-index and activity profiles taken at some intersections of the longitudinal projection C illustrate very well how much we can learn about the streams' structure from regular annual observing campaigns.

Hajdukova [27] has shown that random variations occur in the orbital elements of the comet, a process that could also be responsible for the non-stable mass concentrations in the stream. She has also predicted an effect on the radiant structure. There should be a relatively homogeneous dispersion on the radiant at the sub-minima, but at the sub-maxima, there should be two sub-radiant areas.

Recent details about the radiant area are only mentioned by Jones [20]. He found that the radiant scatter decreases from $\lambda_\odot = 202°$ to $\lambda_\odot = 214°$. We will not go into more details for what the radiant characteristics are concerned. An excellent overview of historical data on the Orionid radiant positions is given by Kronk [28]. It would be interesting to see recent and future data from the *IMO* to resolve the Orionid radiant structure in recent times.

Many people expected an increase in Orionid activity around the passage of comet P/Halley. According to McIntosh and Hajduk [23], the present libration cycle of Halley would coincide with activity at $\lambda_\odot = 202°$. From their telescopic observations, Znojil et al. [29] found evidence for the concentration of faint particles at $\lambda_\odot = 202° \pm 2°$. This area should contain the belt with the youngest particles, weighing less than 10^{-2} g. Unfortunately, this period was not very well covered in 1990. Moreover, observations indicated no increased activity near the parent comet. To make things even worse, the activity at the different sub-maxima during entire shower activity in 1985–1986 was lower than in previous years, and small particles were absent [21]. With the mass index $s = 2.2$, the ratio of faint meteors was much higher in 1980–1983 than in 1985–1986 which gave $s = 1.85$ [30].

These observations however do agree with the theory. Hajdukova et al. [30] concluded that the minimum distance between the present orbit of the comet and the Earth's orbit is too large to observe fresh ejecta in the visual range. A simulation by Babadzhanov et al. [31] proved that particles released from the nucleus in 1985–1986 could not have encountered the Earth yet and will not do so during the next few revolutions of the comet.

These last few lines lead to a pertinent question: How old is the Halley meteor stream? If simulations learn us how many cometary revolutions were necessary to build up the complex stream of ribbon-like belts which consist of super-imposed chains of filaments, and if we know the dimensions of this complex, a rough estimate of the age is possible. Jones, McIntosh and Hawkes [32] estimate the age of the stream to be between 2500 and 62 000 years, the most probable age being 23 000 years. This age was determined from the ratio of the stream's mass to the mass of the comet Halley. Numerically integrating orbital motion of 500 test particles over several millennia confirmed the structure described above and showed that gravitational perturbations, mainly by Jupiter, result in a considerable amount of fine structures in the stream. Particles released in 1404 BC now formed a ribbon-like structure and must be considered as young particles. The Halley stream probably formed after a close approach of P/Halley to Jupiter, 220 revolutions ago, but the comet itself is much older than that [33].

6. Conclusions

Future observations should aim at obtaining more reliable r profiles to confirm the results of this analysis or to modify them. Analyses of the shape of number-density profiles for other major showers will be very useful. The main problem is the determination of a reliable r profile with an adequate resolution. For the Orionids, the resolution of 1 day is still useful but for example for the Quadrantids, this becomes a matter of a few hours. Perseids and Geminids range somewhere in between. A solution could be to use data of different years but this can become problematic if there are inhomogenities in the particle distribution along the orbit which, for example, is evident for the Quadrantids.

To obtain a higher resolution, observers should report their magnitude distributions around the maximum of a major shower for intervals of about 2 to 5 hours each depending on the number of shower meteors seen, rather than for the entire night. The interval length should be chosen in such a way that the magnitude distribution for this interval includes about 50 to 100 shower meteors.

A stream of the complexity of the Orionids deserves even much more attention than what it received through the promotion of the *IHW*. We sincerely hope that the *IMO* will enable us to follow this stream year after year in great detail to solve all the mysteries that are currently around and to reveal unpredictable surprises that are undoubtedly still hidden in the stream!

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Computer Simulation of Earth-Grazing Fireballs

D.W. Olson, R.L. Doescher, K.M. Watson, Southwest Texas State University

A computer simulation is presented for the trajectory of the Earth-grazing fireball observed over Czechoslovakia and Poland on October 13, 1990.

A computer program especially suited to the simulation of Earth-grazing meteors has been listed and described in the Astronomical Computing department of *Sky & Telescope* [1]. The program allows for the curvature of the Earth; it is therefore possible to follow an Earth-grazing meteor as it descends, reaches perigee, and then ascends back into space. Also included is the bending of the meteor's path under the influence of gravity, which can be significant for long-duration fireballs moving on nearly-horizontal paths. The program has been used to simulate the Earth-grazing meteor observed over western North America on August 10, 1972 [1]. The purpose of this note is to show that the program can also be used to simulate the Earth-grazing fireball photographed over Czechoslovakia and Poland on October 13, 1990 [2], and also recorded as a radio meteor [3].

To produce an accurate simulation of the 1990 event, it was necessary to edit several program lines containing parameters related to the speed, mass, and composition of the body. The program listing is as given in *Sky & Telescope* [1], except for three lines which should be modified as follows.

```
26  A = 1:  L = .0044:  G = .5
28  SG = 10^(-7.5)
30  H = 250000:  T = 0:  FM = 10:  FL = FM
```

Here the luminous efficiency (L), appropriate to the observed velocity of 41.5 km/s, is derived from Table 1 of Ceplecha and McCrosky [4]. The value of the ablation parameter (SG), for an ordinary chondrite, is taken from Ceplecha [5]; the density chosen below, equivalent to 3.7 grams per cubic centimeter, also corresponds to that of an ordinary chondrite [5]. In order to begin the simulation at a point well above the observed part of the path, the initial height (H) is chosen to be 250 km above the Earth's surface. The initial zenith angle is then adjusted to produce a grazing trajectory with the correct perigee height. The program prints every tenth time step (FM = 10).

The output includes the position of the meteor, the speed, the atmospheric deceleration, and the mass, expressed as a percentage of the initial mass. The program also tabulates the apparent visual magnitude as it would be observed from the point on the ground track which is directly below the instantaneous position of the meteor and from which the meteor is observed to be passing through the zenith. The computed magnitudes are somewhat uncertain, since the program makes the simplifying assumption that the luminous efficiency remains constant along the path. Another limitation is that the program does not take into account the effects of fragmentation.

With the preceding choices for the variables, the trajectory of the October 13, 1990, fireball is traced in the following dialogue from the program.

```
INITIAL MASS (KG)     ?  40.5
DENSITY (KG/M^3)      ?  3700
SPEED (KM/S)          ?  41.5
ZENITH ANGLE (DEG)    ?  78
TIME STEP (SEC)       ?  .5
```

TIME (S)	GROUND TRACK (KM)	HEIGHT (KM)	SPEED (KM/S)	ATMOS DECEL (M/S/S)	MASS (%)	VISUAL MAG
0	0	250	41.5	0	100	5.7
5	196	209.6	41.5	0	100	3.9
10	395	175.2	41.5	0	100	2.3
15	596	147.1	41.5	0	100	0.7
20	798	125.2	41.5	0	100	-1.5
25	1001	109.7	41.5	0	100	-3.9
30	*1205*	*100.6*	*41.5*	*0*	*99.8*	*-5.7*
35	*1410*	*97.9*	*41.5*	*1*	*99.4*	*-6.3*
40	*1614*	*101.6*	*41.5*	*0*	*98.9*	*-5.4*
45	1818	111.8	41.5	0	98.8	-3.5
50	2022	128.3	41.5	0	98.8	-1.2
55	2224	151.2	41.5	0	98.8	1.1
60	2424	180.3	41.5	0	98.8	2.5
65	2623	215.7	41.5	0	98.7	4.1
70	2819	257.1	41.5	0	98.7	6.0

The three italicized lines correspond to the 10-second interval of observations, during which the meteor moved over a ground track of about 409 km. For this meteor near perigee, coincidentally, the apparent magnitude and the absolute magnitude are nearly equal. The values for the maximum brightness (absolute magnitude −6.3), perigee height (97.9 km), and the mass loss (0.9%, or from about 40.4 kg to 40.0 kg, during this interval) are in good agreement with the reported observations [2].

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Brightness Distribution of Meteors and Fireballs

V.V. Martynenko and A.S. Levina

About 16 000 meteor data gathered in the USSR during the period 1957–1975 were used to determine meteoroid flux as a function of magnitude. The luminosity function thus obtained shows a distinctive bend between magnitudes −6 and −8. In general, our results agree well with those obtained in other studies.

To obtain quantitative characteristics of the complex of meteor matter in the Solar System is a well-known problem that visual observations must decide. These characteristics are meteoroid flux (number of particles of different mass per square meter and per second), spatial density (number of particles per cubic meter) etc. They can be obtained by analyzing a lot of statistically uniform observational data over a long period. Precisely these kind of data are in the archives of the Crimean Zateishchikov Meteor Station of the All-Union Astronomical-Geodetical Society of the Academy of Sciences of the USSR and the Crimean Regional Observatory of the Young Technicians Station. More than 280 000 meteors have been counted over a period of 35 years. Among them, 150 000 were selected for the study of meteor and fireball number in the magnitude range from +9 to −15. This sample was extensively analyzed during the International Geophysical Year (1956-1957) and the Year of the Calm Sun (1963-1964), then from 1966 to 1967, and from 1971 to 1988. More than 250 experienced observers from the Crimea (Simferopol, Sudak et al.), Moscow, Donetsk, Ufa, Yaroslavl and many other towns took part in these observations [1–5].

From 1971 on, the observations were realized according to the program "All-sky" for the visual fireball observations, including the determination of the magnitude (m) and zenith distance (Z) of bright meteors in fields around the zenith of 90°, 140°, 160° and 180° diameter, that allowed correcting the collecting area during the treatment. It is necessary to take into account that the value of Z was determined as the distance from the zenith to the brightest part of the meteor.

In this study, only a part of all data was used. There are 15 986 meteors of magnitude +3 to −6 in the period 1957–1975 in the area around the zenith with diameter about 60°–70° and 44 fireballs between −5 and −15 in that same period. There are not so many data in the range −4 to −6 for observations around the zenith. Therefore, an additional 132 bright meteors from −2 to −7 were analyzed too, obtained between 1972 and 1975 by observations around the zenith in a region with a diameter of 70°. Fireballs, obtained during radiant studies, photographic sky patrols, etc., were not included in this research, except if they were brighter than −10. Including weaker fireballs could have introduced some uncertainty in the net time of observing.

Table 1 – Distribution of the observing time (in percentage)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1957–1971	2	2	4	3	3	18	24	26	6	3	3	6
1972–1975	1	0	0.2	0.3	2	16	21	56	2	0.6	0.6	0.3
Total	2	1	2	2	2	20	24	36	3	2	2	6

The observing time was distributed as shown in Table 1: 80% of it fell during the summer months, when regular Crimean meteor expeditions were organized; 6% fell during the December showers (Geminids and Ursids); the remainder of the observing time was distributed evenly among the other months.

As a result of the treatment we must obtain the integral meteor flux $F(m)$, calculated according to the formula:

$$F(m) = \frac{N(m)}{TS} \tag{1}$$

with $N(m)$ the total number of meteors of a given magnitude, T the net observing time, and S the surface of the collecting area (cross section). We used meteor numbers without perception coefficients, because the group of experienced observers recorded almost all meteors brighter than magnitude +3 [6]. For the calculation of $F(m)$, however, we have introduced the special effective areas $S_{\text{eff}}(m)$ for every value of the magnitude, expressed by:

$$S_{\text{eff}}(m) = 2R\lambda + \pi R^2 \tag{2}$$

whith R the radius of the observed zenith region, and λ the angular length of meteors and fireballs for a given magnitude, as estimated by Crimean observations (see also Table 2). For fireballs brighter than −10, S_{eff} was determined graphically taking into account the Earth's curvature and the altitudes where the maximal brightness of meteors occurs [3].

Table 2 – The relationship between average meteor length and absolute magnitude.

m_z	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3
$\overline{\lambda}$	45°	43°	40°	35°	33°	30°	26°	23°	20°	16°	12°	10°	6°

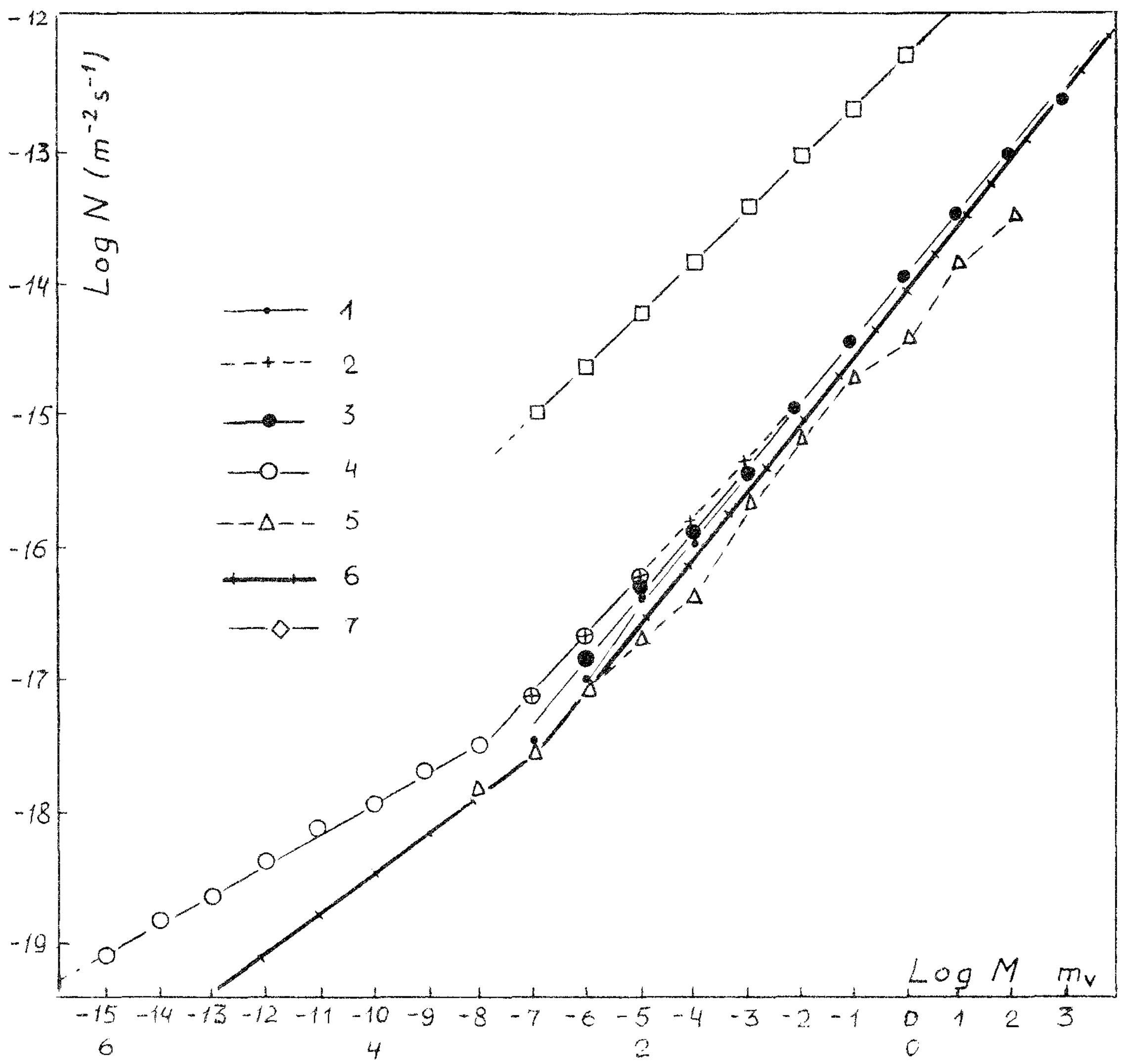

Figure 1 – (1) Luminosity function of the 1957–1975 observations in the zenith area with 60° diameter; (2) id., for the fireballs service (∅ = 70°) in 1972–1975; (3) id., for the bright fireballs for the entire period 1957–1975; (4) id., for the 1976 Perseids; (5) id., for the 1980 Perseids; (6) Whipple general dependence for meteors between −15 and +3 if it is assumed that magnitude 0 meteors correspond to a mass of 1 gram; (7) dependence by McKinley.

Results are listed in Table 3 and illustrated in Figure 1. For ranges from +3 to −6 and from −8 to −13 we got $\kappa = 2.95$ and $\kappa = 1.82$ respectively. Apparently, the break in the luminosity function is real, as it is confirmed by other methods of calculation. For comparison, values of $F(m)$ for the 1980 Perseids are shown in Table 4. This agrees with results from Rendtel and Knöfel [7]. They calculated the value of κ as 2.6 to 2.9 for the magnitude range from −5 to +5 and as 1.4 to 1.8 for the range from −10 to −20.

Table 3 – Number of fireballs and bright meteors in the Crimea during 1957–1975. m_z is the zenithal (absolute) magnitude, n_i is the registered number of meteors, ΔT is the net observing time in hours, S is the observed area in 10^3 km^2, $\emptyset$ is the diameter of the observed area in degrees, R is the observed area in km, and N is the integral flux of meteors brighter than the given magnitude in $s^{-1}m^{-2}$.

Meth.	Count $\emptyset = 70°$ 1957–1975			Count $\emptyset = 60°$ 1957–1975			Fireballs $\emptyset = 70°$ 1972–1975			Integral flux	
m_z	n_1	ΔT	S	n_2	ΔT	S	n_3	ΔT	S	$\log \frac{N_1+N_2}{2}$	$\log N_3$
+3	4394	576	17.7	4438	675	12.1				−12.65	
+2	1794	576	18.6	2023	675	13.3				−13.06	
+1	751	576	20.1	978	842	13.7				−13.50	
0	272	576	20.6	369	842	14.1				−13.96	
−1	95	576	21.6	128	842	14.9				−14.45	
−2	40	576	24.9	34	842	17.2	83	1223	24.9	−14.95	−14.93
−3	12	576	26.6	15	842	18.1	29	1223	28.3	−15.45	−15.42
−4	5	576	28.3	4	842	19.6	13	1223	28.9	−15.95	−15.81
−5	2	604	31.4	2	842	20.6	4	1223	29.5	−16.43	−16.23
−6	1	604	31.4				2	1223	30.8	−17.13	−16.66
−7							1	1223	33.3		−17.17
Tot	7320			8666			132				

Table 3 – continued.

Meth.	All-sky $\emptyset = 180°$ (1957–1975)					Integral flux
m_z	n_4	$\emptyset$	R	S	ΔT	$\log N_4$
−05	21	140°	180	101.7	1358	−16.20
−06	7	140°	180	101.7	1358	−16.69
−07	5	150°	230	166.1	2351	−17.21
−08	2	150°	230	166.1	2351	−17.53
−09	2	160°	310	301.8	2351	−17.78
−10	1	160°	310	301.8	2351	−18.02
−11	2	170°	470	693.6	2351	−18.21
−12	1	170°	470	693.6	2351	−18.48
−13	1	175°	600	1141	3914	−18.73
−14	1	175°	600	1141	3914	−18.91
−15	1	175°	600	1141	3914	−19.21
Tot	44					

Table 4 – The relationship between m_z and $\log N$ for the 1980 Perseids.

m_z	−7	−6	−5	−4	−3	−2	−1	0
$\log N$	−15.00	−14.60	−14.20	−13.85	−13.40	−13.10	−12.70	−12.25

The same investigation had earlier been done by the American Meteor Society and was summarized by C. Olivier [8]. It contains 71 490 meteors and fireballs from −10 to +6. The meteor series 20 033 and 10 287 in the periods from 1933 to 1941 and from 1947 to 1956 respectively were published by P. Millman for magnitudes from −6 to +6 [9]. Prentice sorted out about 1028 meteors from −2 to +5, which had been obtained by the BAA. From the British observations, absolute magnitudes could be derived [10].

An attempt of determining the luminosity function using various types of instruments was made in Czechoslovakia and repeated in the Crimea from 1966 to 1967 [11].

Our luminosity function is like Whipple's [12] general dependence through the whole range of magnitudes, but as we observed, the number of bright meteors and fireballs was higher. Perhaps, this is connected with the predominance of observation periods with increased meteor activity. The mutual proximity of luminosity functions in Figure 1 shows the reliability of our method. The American photographic network determined the luminosity function within the range from −16 to −3, with a result very similar to ours. However, the small samples for bright fireballs must caution us not to make premature conclusions and to carry out further observations.

P. Babadzhanov et al. [13,14] have obtained the mass distribution from photographic and radio observations in Dushanbe for the Perseids:

$$\log N_0(M) = -14.2 - 0.67 \log M$$

and for the sporadic meteors:

$$\log N_0(M) = -13.7 - 1.1 \log M$$

whith M the mass of meteor (gram), N the number of meteors per square meter and per second for the Perseids, and $[N(M)] = \mathrm{m}^{-2}\mathrm{s}^{-1}.2\pi$ for the sporadics. In Table 3, we obtained for the Perseids:

$$\log N_0(M) = -14.7 - 0.98 \log M$$

and for the sporadic meteors:

$$\log N_0(M) = -15.04 - 0.65 \log M \text{ (interval from } -15 \text{ to } -8)$$
$$\log N_0(M) = -15.76 - 1.17 \log M \text{ (interval from } -7 \text{ to } -3)$$

Values of constants are different because of various methods of observations, errors in the determination of the time and collecting areas, and the inaccuracy of determining the meteor's magnitude and the meteoroid's mass.

The authors of [14] obtained $N(10^2) = 4.47 \times 10^{-7}$ m²s^{-1}, while the authors in [15] got $N(10^2) = 8.3 \times 10^{-8}$ m²s^{-1}. From Table 3, we obtained $N(10^2) = 1.67 \times 10^{-7}$ m²s^{-1}.

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Unusual Meteor Track

Gotfred Møbjerg Kristensen

The author observed a bended meteor track on May 12, 1991, at $22^h54^m56^s$ UT.

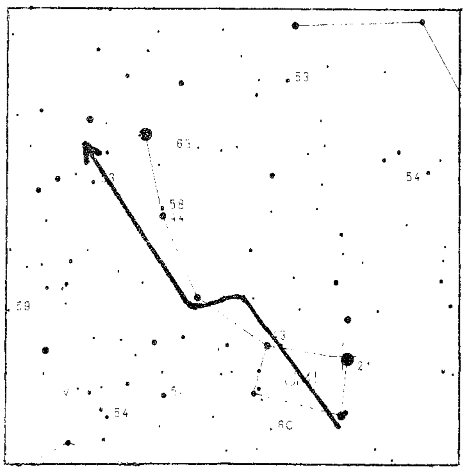

Figure 1 – The bended meteor track.

I observed a very unusual meteor track in the night of May 12-13, 1991, at $22^h54^m56^s$ UT. The meteor had a magnitude of +2.5, was rather fast, blue, and without train. The track was clearly bended, as shown in Figure 1. The observation is reliable because I was looking directly at Ursa Minor when the phenomenon occurred. The meteor might have been a sporadic or could also have belonged to the Virginid complex. It produced a short, well-defined radio signal, registered with my pen recorder. I observed during 1 hour and 51 minutes that night, under a sky with a limiting magnitude of +6.0.

I would like to receive a good explanation why a meteor can change its direction as dramatically as the one I saw. Can this perhaps be due to a spinning effect, or could conditions in the upper atmosphere be responsible?

A meteor entering the atmosphere under a very low angle can bounce back on a layer of thicker air, more or less in the same way as a stone can be thrown to bounce back on a water surface. (Ed.)

Impact of a Veined Meteorite in China

Sichao Wang, Purple Mountain Observatory

An account is given of the impact of a veined meteorite in China that occurred on August 15, 1989, at 12^h53^m UT.

A stone meteorite of about 400 g hit the roof of a house at $\lambda = 119°52\rlap{.}'3$ E and $\lambda = 32°25\rlap{.}'9$ N, near the town of Sixiangkou in China, on August 15, 1989, at 12^h53^m UT (which is 21^h53^m Beijing Summer Time).

The meteorite fragmented into three pieces, the largest of which weighs about 300 g (see Figure 1). All the material was recovered from the roof of the house and a vegetable field on the day of the impact. Investigations are being carried out at the Purple Mountain Observatory by the present author.

Several hundred thousands of people in the Jiangsu Province saw the fireball that dropped the meteorite. It was brighter than the Full Moon and lasted for about 15 seconds. A sonic boom was heard by about one hundred thousand persons. Some of the eyewitnesses reported fragmentation: the large fireball split into one smaller fireball and four other meteors.

Preliminary calculations carried out by the author indicate that the meteor traveled from the NNW to the SSE over a distance of about 150 km.

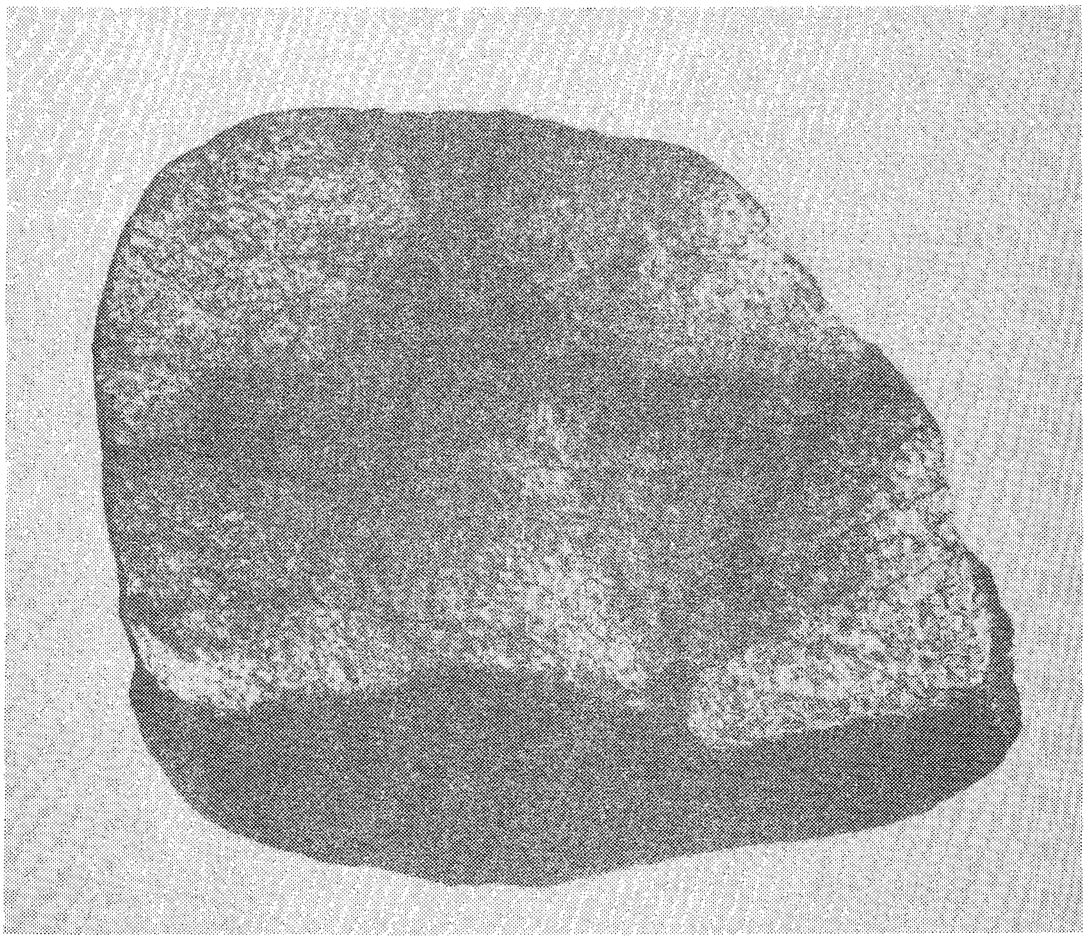

Figure 1 – The largest of three fragments of the meteorite that fell on a house at $\lambda = 119°52\rlap{.}'3$ E and $\lambda = 32°25\rlap{.}'9$ N, near the town of Sixiangkou, China, on August 15, 1989, at 12^h53^m UT, on scale 2:1. This fragment weighs about 300 grams.

Telescopic Observations of Geminid Persistent Trains

Mark Vints

On the night of the 1990 Geminid maximum, four meteors observed with a 10 × 50 binocular displayed persistent trains lasting from 25 to 120 seconds. An account is given of some theoretical and observational aspects of persistent meteor trains.

1. Observations

December 13-14, 1990, in Lardiers, France: cold, windy and perfectly clear. The Geminid maximum display has been going on for hours, and telescopic observations are going fine. The 10 × 50 binoculars (6°.2 field diameter) are aimed at μ Geminorum. At 3^h01^m UT a magnitude +1.5 Geminid flashes through the field of view. A "telescopic fireball" like this is rather rare, and "makes" the night. Most stunningly however: a delicate persistent train, slowly being distorted in the upper atmosphere winds, and fading until it has gone after 30 seconds (see Figure 1, top).

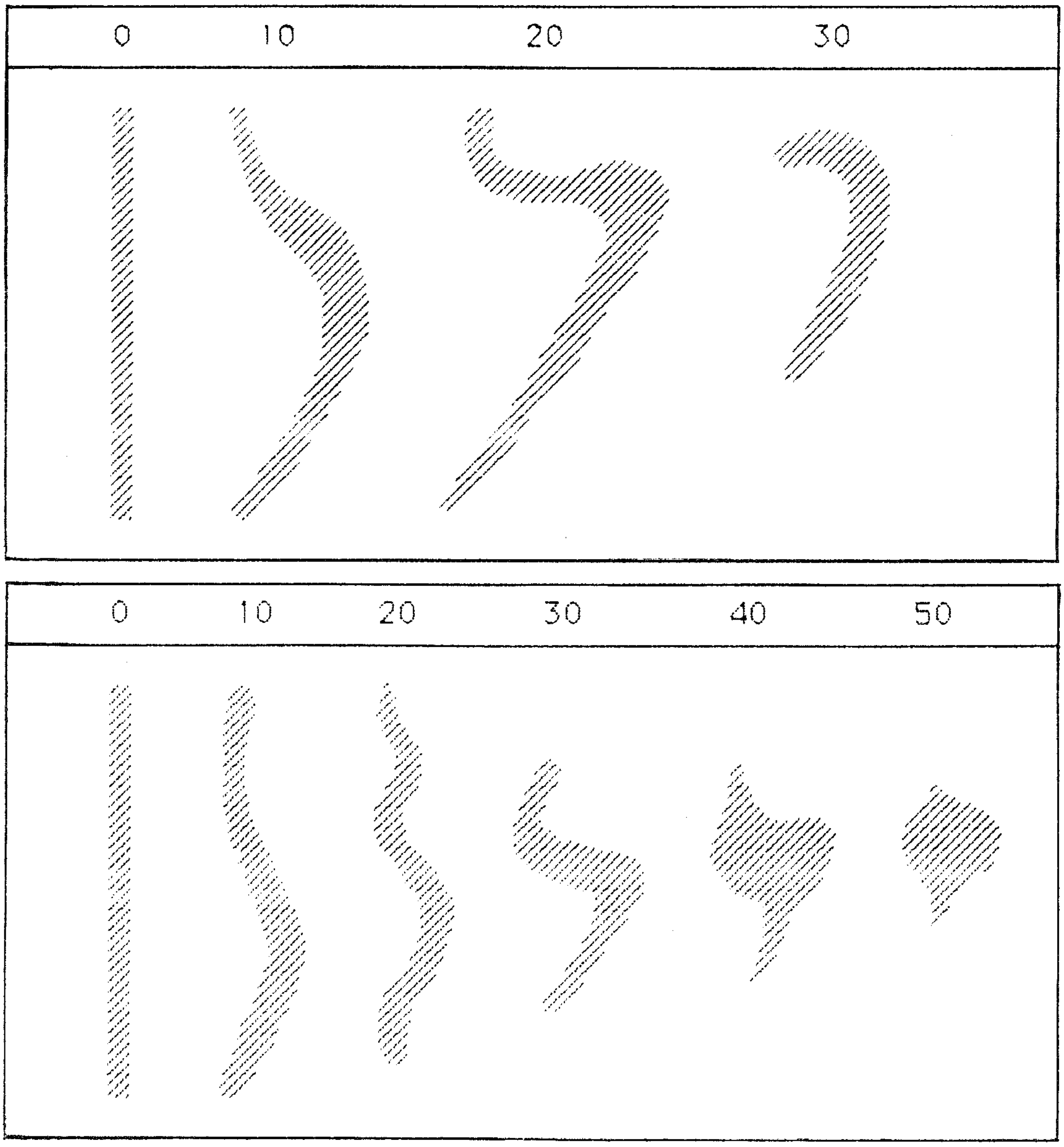

Figure 1 – Persistent trains of telescopic meteors on December 13-14, 1990, at 3^h01^m UT (top) and 4^h35^m UT (bottom).

Some 22 meteors later, at 4^h35^m UT, a magnitude +1.0 Geminid crossed the field in Auriga. A bright persistent train remains, being distorted more strongly than the previous one (see Figure 2, bottom) and lasting up to 50 seconds. These two events really gave me a taste for train-hunting, so after the observations had ended, I stayed outside looking for bright meteors.

At 4^h52^m UT a −3 Geminid is visible low in the west. After running to the binoculars some 10 meters distant, I easily spot the persistent train. At first, it looks like an upside-down balloon, then it grows into a whale, and finally, it breaks into pieces. In total, it lasted about 2 minutes (Figure 2). Only 8 minutes later, a magnitude 0 Geminid passes almost overhead. The binoculars show a distorting and rapidly moving train for about 25 seconds (Figure 3). Besides their beauty, the four trains had one other thing in common: they were not visible to the naked eye.

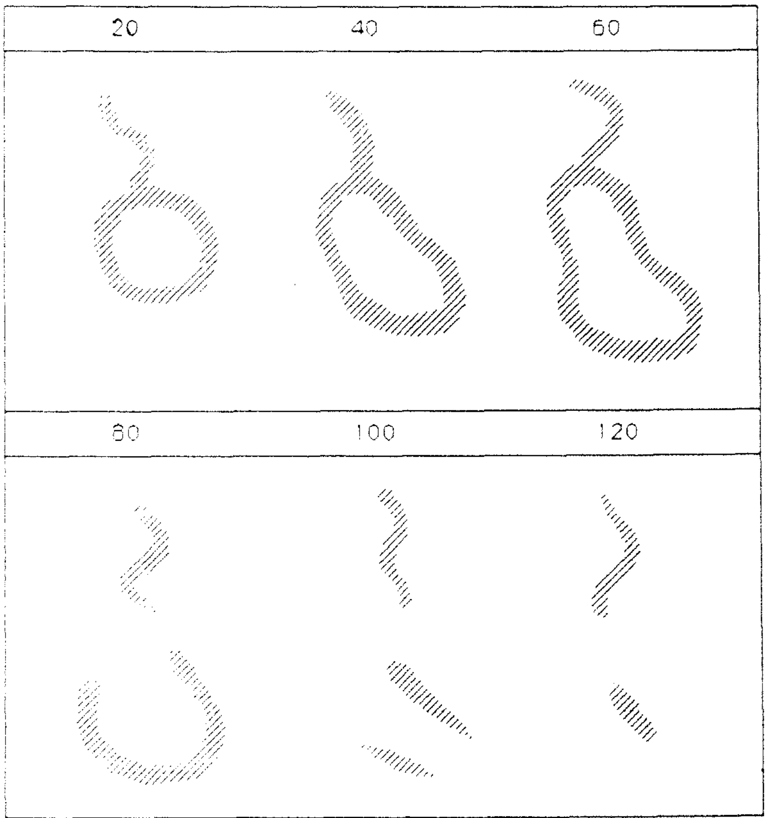

Figure 2 – Persisting train of a −3 Geminid on December 13-14 at 4^h52^m UT seen through binoculars.

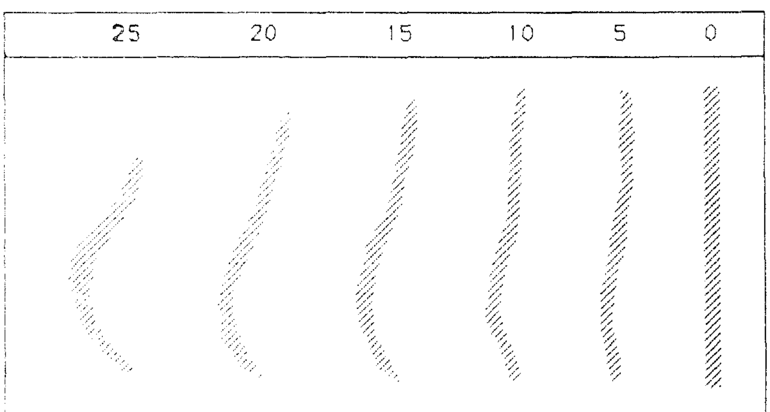

Figure 3 – Persisting train of a magnitude 0 Geminid on December 13-14 at 5^h00^m UT seen through binoculars.

2. General remarks on persistent trains

Collisions between meteoric and atmospheric atoms and molecules result in excitation and ionization of these particles [1]. This gives rise to the ion-electron train which is detected in radio observations. It can sometimes be visible to the naked eye as a so-called persistent train for some seconds or even minutes.

Almost every meteor entering the atmosphere produces an ion-electron train, since even very small meteor masses can be observed by radio techniques. Yet we know from visual observations that different showers have different percentages of train-forming meteors [2]. For instance, the Perseids show about 40% trains, the Lyrids some 15%, and the Geminids only 5%. So the question arises as to what determines the visibility of these trains.

Reports in the literature are unanimous on one fact: faster meteors produce more trains [1,3,4]. This is not very surprising since collisions at higher speeds give rise to more excitation and ionization. And checking the three showers I quoted from [2] confirms this relationship.

For a given meteor velocity, the other important parameter is train duration. Primarily, the train duration increases with increasing meteor brightness. This effect is most pronounced for meteors between magnitudes -3 to -8, and less for either fainter or brighter meteors [4]. Other factors which influence train duration are the local time, geographical latitude and the solar activity.

On a molecular level, disintegration of the ion trail results from a number of processes which either destroy the ionization or spread it out over a larger volume [1]. It is believed that for durations below about 50 seconds, the main limiting factor is attachment of the electrons to oxygen molecules in the air. For durations in excess of 50 seconds, turbulent diffusion of the trail becomes the most important.

The long durations of some persistent trains offer a way of studying wind patterns at meteor heights. Typical train drifts are predominantly horizontal at about 50 m/s [5]. Different wind currents are spaced at 5 to 10 km, and cause differential motions of about 25 to 90 m/s. A complete study of the wind patterns on a local or global scale requires meteor radar techniques [6] to amass enough data. Reports from different radar facilities show that the wind regime at meteor heights is a superposition of several components: *(i)* a prevailing wind which only changes on a time scale of months, *(ii)* planetary waves of a period longer than a day, *(iii)* regular motions from atmospheric solar heating, a diurnal and a semi-diurnal tide, *(iv)* internal gravity waves, and *(v)* random turbulent motions.

For interested observers it is worthwhile to further study train phenomena for different meteor showers in different years and also using optical aids. And it would be fun to derive wind pattern, even from a few plotted trains.

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Parallel TV and Telescopic Observations of the 1991 Perseids in Czechoslovakia

Petr Pravec

A project is presented for parallel observations of the 1991 Perseids from Ondřejov Observatory, both telescopically and by means of a TV-camera.

From August 8 to 16, 1991 parallel observations of the Perseid meteor shower telescopically and by means of a TV-camera will be performed at the Ondřejov Observatory in Czechoslovakia. These observations constitute an extended part of the 1988–1992 Perseid Project.

The major goal of this project is monitoring the activity of telescopic Perseids before and during the possible return of their parent comet P/Swift-Tuttle in 1992 [1]. This project will be described in a future article. (Preliminary information: from 1988 to 1990, we have obtained about 3500 records of telescopic meteors around the Perseid maximum.)

The second, but also very important goal of these parallel observations is to find out the correlation between records of the same meteors obtained by means of both techniques. Around the maximum of the Perseids, a group of about ten telescopic observers and our TV-camera will watch the same area in the sky (at a distance of 13° from the Perseid radiant) every clear night. Some parameters of the TV-camera: field of view: $14\overset{\circ}{.}7 \times 11\overset{\circ}{.}0$, star limiting magnitude: approximately +8 (It is +11 when watching the screen during observation, but it is very much reduced by recording on videotape.) Parameters of our telescopes: 10×80 binoculars, diameter of the field of view: $7\overset{\circ}{.}4$, star limiting magnitude: +10.5–+11. In case of several clear nights, we expect to catch several tens of meteors by means of both techniques.

A few other groups of telescopic observers will also perform observations within the 1988–1992 Perseid Project in Czechoslovakia, this year. We hope to obtain valuable data about the telescopic activity of the Perseids in 1991.

Reference

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Possible Meteor Activity Associated with Comet Levy

communicated by Peter Brown

The newly discovered Comet Levy (1991 q) is a potential source of meteor activity. The orbital data on IAU Circular 5306 suggest that activity of any associated meteor shower can be expected on Aug 30.97 UT. The corresponding radiant would be at $\alpha = 321\overset{\circ}{.}9$ and $\delta = -62\overset{\circ}{.}1$ (1950.0). Hence, it is recommended that observers in the southern hemisphere keep a special watch on this date and perhaps several days on either side of August 31. The separation of the orbit of the Earth and comet Levy at this time will be 0.075 AU. The calculated geocentric velocity of the associated meteors is 18.7 km/s. This information was communicated to Dr. J. Watanabe from Mr. K. Ohtsuka. Prof. I. Hasegawa hopes to give this information to members of IAU Commission 22 during the IAU General Assembly.

Our readers are kindly requested to communicate their experiences to the Editor-in-Chief who will forward them to Dr. Watanabe.

Large-Scale Structure of the Perseid Meteor Shower from Long-Basis Observations

A.I. Grishchenyuk

The existence is examined of large-scale structures in the Perseid stream. For this, meteor counts in subsequent short-length intervals from several stations were correlated. In addition, a joint cross-spectral analysis was performed using FFT techniques on the data of August 12-13, 1986. The results indicate that large-scale structures were only evident in the early '80s, which may have been caused by the parent body's encounter.

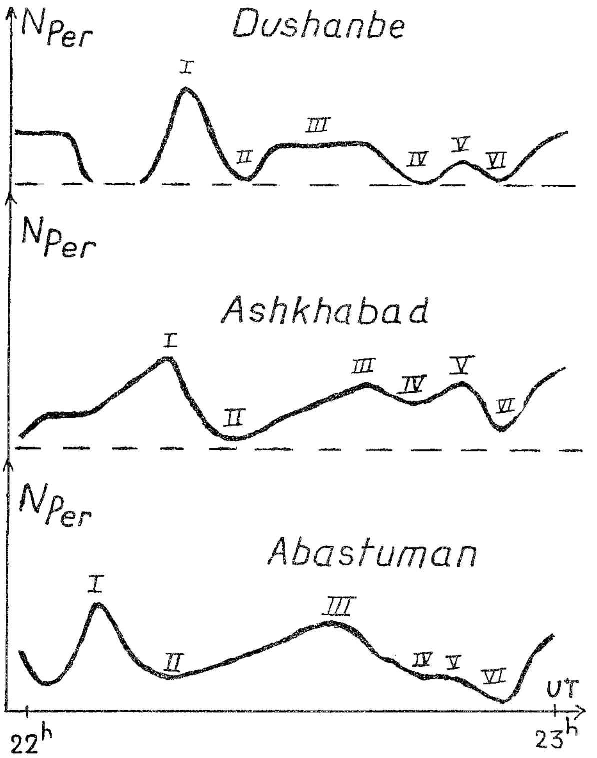

Figure 1 – Simultaneous meteor observation with a 4000 km basis demonstrate the drift of "clouds" (I, III, V) and "gaps" (II, IV, VI). The observations refer to the period on August 12, 1951, between 22^h and 23^h UT. (After [2].)

Besides probably existing [1] small-scale complexes of meteor bodies one can also observe larger-scale structures that can be seen during 5–10 minutes. We call them "meteor clouds". Such structures were discovered when processing the Perseid observations performed in 1950, 1951 and 1953 on the initiative of I.S. Astapovich, carried out simultaneously at the observatories of Dushanbe, Ashkhabad, Abastuman and Odessa.

Clouds can have different sizes: some of them pass through the Earth's atmosphere during 10 to 30 seconds and contain only a few meteors (a group), while others have a diameter of about 1000 km and can be seen from sites 1000 km apart. Even larger clouds can be registered over the entire night hemisphere. Figure 1 shows short-term activity profiles of the Perseids collected from three of the sites [2]. Perseid data were taken from [3] as material for further processing.

Long-basis observations were carried out again in the USSR in 1980 from Ashkhabad, Novotroitsk and Sudak; in 1982 from Sudak, Alma-Ata and Sanglok (near Dushanbe); and in 1986 from Zelenchuk (in the northern part of the Caucasus) and Sudak (Simferopol). For all the basis groups (except 1986), correlation coefficients were calculated for series of meteor numbers in subsequent five-minute intervals. Series for the eastern groups (Dushanbe in 1951, Ashkhabad in 1980, and Alma-Ata and Sanglok in 1982) were shifted by 5 minutes in forward direction. The results are given in Table 1.

Table 1 – Correlation coefficients for series of meteor numbers in subsequent five-minute intervals.

Date	Period (UT)	Basis	Per	Corr.
1951, Aug 10	19^h00^m–20^h00^m	Dushanbe-Abastuman	65	0.53
1951, Aug 10	19^h00^m–20^h00^m	Ashkhabad-Abastuman	75	0.13
1980, Aug 11	18^h00^m–19^h30^m	Ashkhabad-Novotroitsk	313	0.88
1980, Aug 11	18^h00^m–19^h00^m	Sanglok-Sudak	135	0.83
1980, Aug 11	19^h00^m–20^h00^m	Sanglok-Sudak	145	0.53
1980, Aug 11	20^h00^m–21^h00^m	Sanglok-Sudak	175	0.85
1980, Aug 11	18^h00^m–19^h00^m	Alma Ata-Sudak	175	0.87

Figure 2 shows meteor number profiles averaged over 10-minute intervals for the Ashkhabad and Novotroitsk groups on August 12-13, 1980. Figures below lines mark traversals through the Earth's atmosphere of large clusters of meteoroids registered by both groups.

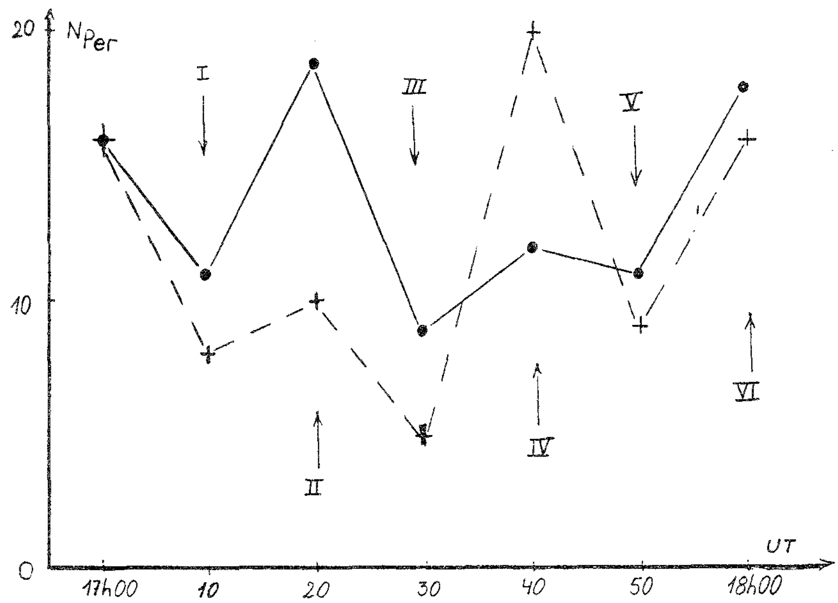

Figure 2 – Perseid number profiles averaged over 10-minute intervals for the Ashkhabad (crosses) and Novotroitsk (dots) groups on August 12-13, 1980.

Table 2 – Correlation coefficients for different working intervals.

Interval	Per	Corr.	Interval	Per	Corr.
2 min	562	+0.13	4 min	561	+0.04
3 min	557	−0.11	5 min	550	+0.16

Besides this, when the 1986 observations were processed, Perseid numbers for 2- to 5-minute intervals were analyzed. In Table 2, the correlation coefficients for different working intervals are listed. They tend to be near zero in general, but one can see that during quite large time intervals, correlation coefficients are significantly larger. For instance, between 23^h16^m and 23^h44^m UT on August 12, 1986, we obtained a value of 0.9 (an almost synchronous evolution of the shower rate), marked by A in Figure 3, but for the next 28 minutes, a correlation coefficient of −0.9 was obtained (!) (asynchronous evolution), marked by B. It is an important fact that for two nearby points (Sudak-Simferopol: ca. 100 km), the correlation coefficient was almost constant (in the range 0.92–0.97; calculated for verification purposes).

Data obtained on August 12-13, 1986 by the groups in Sudak and Zelenchuk were also processed using the *Fast Fourier Transform (FFT)* with a Bartlett window [4]. FFT is a very powerful mathematical tool which nevertheless demands a careful search for an adequate physical model. Observing meteor showers from two sites, separated in latitude and/or longitude, we obtain two time realizations of the same stochastic process. Results of the joint cross-spectral analysis give us answers to the following questions:

1. Can we distinguish some oscillations with specified frequencies in those time series. What are their periods?
2. Do they equal one another? Knowing periods found to be equal at both stations, can we define characteristic sizes of the formations that caused such oscillations?
3. How coherent are these oscillations in the data from both Sudak and Zelenchuk?

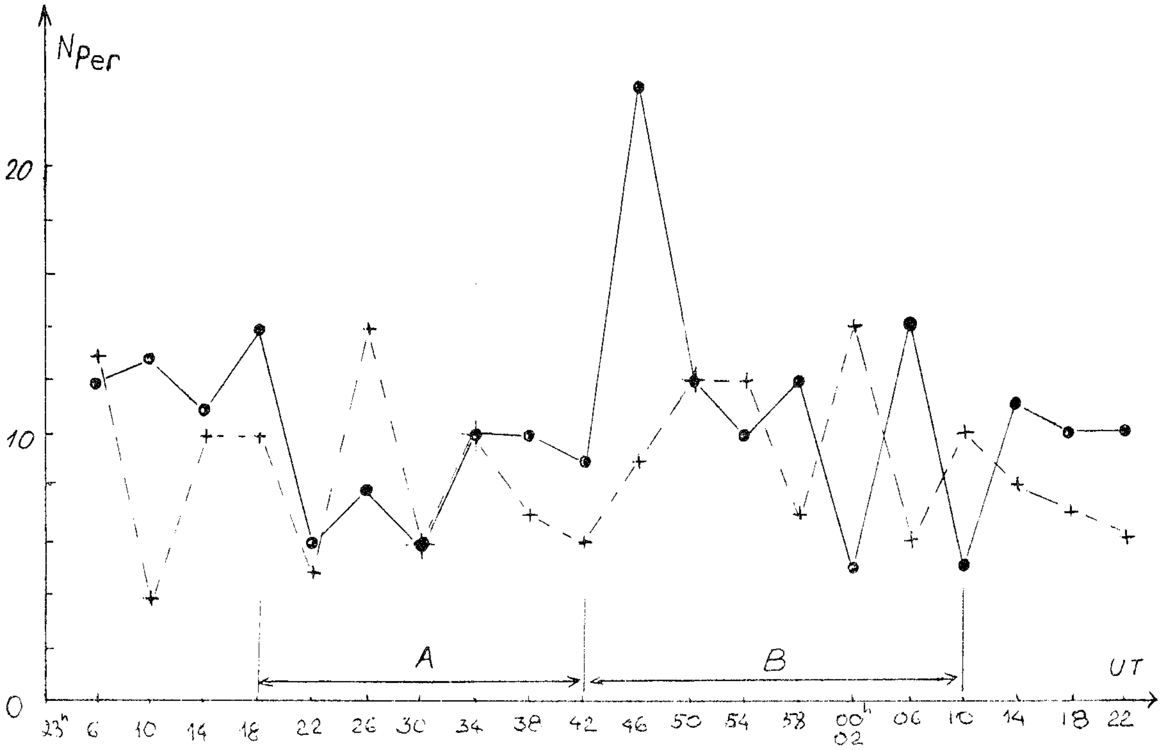

Figure 3 – Perseid number profiles averaged over 4-minute intervals on August 12-13, 1986 from Sudak (crosses) and Zelenchuk (dots). Please refer to the text for further explanations.

We briefly describe the method we used. We assume that the raw material is expressed as a function of time $x_i(t)$, $i = 1, 2$ (the number of the station). We then have an amplitude spectrum:

$$A_{12}(f) = \left(L_{12}^2(f) + Q_{12}^2(f)\right)^{1/2} \tag{1}$$

where:

$$L_{12}(f) = \sum_{k=1}^{N} l_{12}(k) w(k) \cos\left(\frac{\pi k f}{N}\right) \tag{2}$$

is a co-spectrum describing a synchronous relation between processes 1 and 2; and:

$$Q_{12}(f) = \sum_{k=1}^{N} q_{12}(k) w(k) \sin\left(\frac{\pi k f}{N}\right) \tag{3}$$

is a quadrature spectrum for asynchronous variations. In these expressions, $w(k)$ is proportionate to the Bartlett lag window and:

$$\begin{cases} l_{12}(k) = \frac{1}{2}\left(c_{12}(k) + c_{12}(-k)\right) \\ q_{12}(k) = \frac{1}{2}\left(c_{12}(k) - c_{12}(-k)\right) \end{cases} \tag{4}$$

with $c_{12}(k)$ the cross covariancy of time realizations 1 and 2. The squared coherency is then given by:

$$K_{12}^2(f) = \frac{L_{12}^2(f) + Q_{12}^2(f)}{C_{11}(f) C_{22}(f)} \tag{5}$$

where $C_{11}(f)$ and $C_{22}(f)$ are the autospectra of the processes 1 and 2:

$$C_{ii}(f) = \sum_{k=1}^{N} c_{ii}(k) w(k) \cos\left(\frac{\pi k f}{N}\right) \tag{6}$$

for $i = 1, 2$, with c_{ii} the autocovariancies:

$$c_{ii}(k) = \frac{1}{N} \sum_{t=1}^{N-k} (x_i(t) - \overline{x}_i)(x_i(t+k) - \overline{x}_i) \tag{7}$$

Finally, the phase shift is given by:

$$F_{12}(f) = \text{arctg}\left(-\frac{Q_{12}(f)}{L_{12}(f)}\right) \tag{8}$$

The squared coherency $K_{12}^2(f)$ and the phase shift $F_{12}(f)$ were calculated for each harmonic.

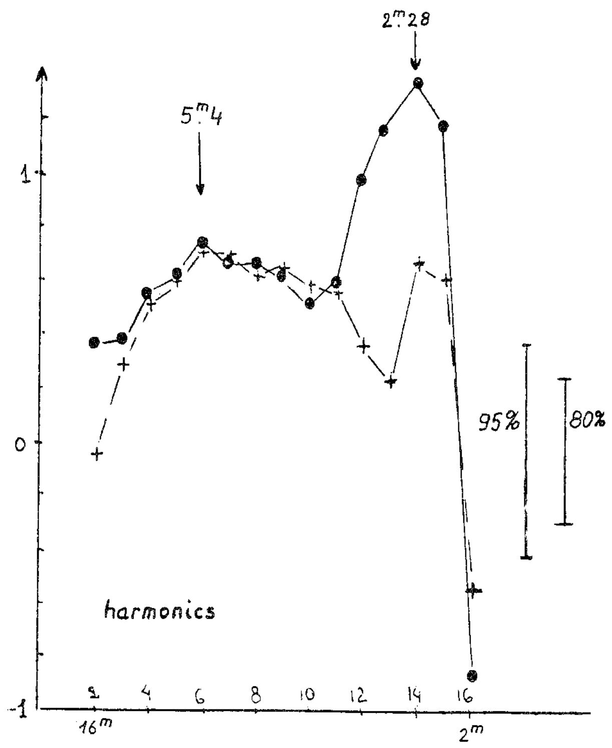

Figure 4 – Power spectrum obtained from 1986 August 12-13 observations (fifth array for both points). 95% and 80% confidence intervals are shown. Logaritmic ordinates are used to maintain constant sizes for the confidence intervals.

By using the coherency and the phase shift we can compare the realizations 1 and 2. As data input, 10 time series of 32 minutes each were used. They consisted of 1-minute Perseid rates for a group of 6–7 observers. We used 290 Perseids from Zelenchuk and 271 Perseids from Sudak, registered between $22^{\rm h}00^{\rm m}$ and $2^{\rm h}30^{\rm m}$ UT, on August 12-13, 1986. The Nyqvist period is 0.5 minutes, since the length of the cumulation interval is 1 minute. "Raw" series were tested for randomness by formula (9) with the $t_\pm$ criterion:

$$t_\pm = \frac{n_\pm - N/2}{\sqrt{(N+1)/K}} \tag{9}$$

where $n_\pm$ is the number of increases/decreases in the raw series, N the numbers of points, and K the number of series. The 95%-confidence interval corresponds to a value for $t_\pm$ of 1.96. The values found for $t_\pm$ varied between 1.50 and 1.92 and hence did not exceed this limit. For the spectral evolution (Figure 4) confidence intervals of 95% and 80% were chosen [5].

Table 3 lists significant periods for both groups. It should be noted that there are almost no large-scale formations; a 10-minute period occurs only once. Most periods are about 2–3 minutes. This fact matches well with the conclusions of the correlation analysis. Some periods revealed at both stations are of particular interest (see Table 4).

Table 3 – Significant periods (minutes) per group and per array.

Group	Conf.	1	2	3	4	5
Zelenchuk	95%		2.0;2.7;8.0	2.0;6.4	2.0;10.7	2.3
	80%		3.2	2.7	6.4	5.3
Sudak	95%	8.0		2.0;3.5	2.0;2.7;4.5	2.3
	80%		3.2			5.3

Table 4 – Analysis of the major periods displayed in Table 3

Period	Q_{12}	C_{12}	K^2_{12}	F_{12}	Array	Conf.
3.2	−0.7	+0.4	0.1	300°	2	80%
2.0	−0.7	+7.2	1.0	355°	3	95%
2.0	−4.3	−5.8	1.0	216°	4	95%
2.3	−8.1	+1.2	0.7	278°	5	95%
5.3	+6.6	−4.0	0.6	171°	5	80%

The period of about 2 minutes exhibits itself both in the Sudak and Zelenchuk power spectra in three arrays of data simultaneously with 95% confidence. High values of coherency demonstrate close connections, especially in the third array ($F_{12} = 355°$, $C_{12} = +7.2$), where "clouds" were observed from both stations at the same time. In the fourth and fifth arrays, the connection is close too, but asynchronous ($F_{12} = 216°; 278°$, $C_{12} = -5.8; +1.2$, respectively). Obviously this is due to the isotropic distribution of the shower particles across the orbit whence the two stations saw the shower in the same way. In the third and fourth arrays the shower probably looked as in Figure 5, and an additional time shift appeared.

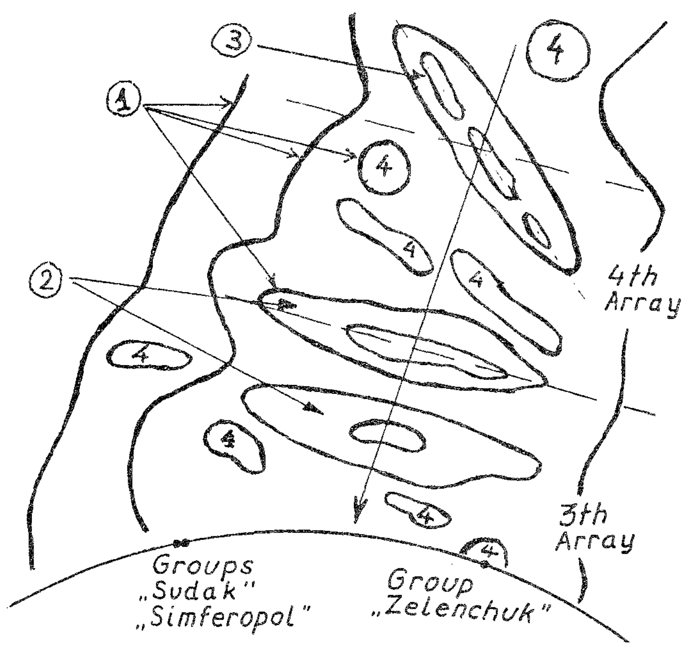

Figure 5 – The shower structure in the third and fourth arrays: (1) lines of equal density; (2) large clouds, synchronous connection; (3) large clouds, asynchronous connection; (4) small clouds.

With 80% confidence we get two more faint periods: 3.2 minutes for the second array, and 5.3 minutes for the fifth, but the very low coherency and the high value of the quadrature spectrum again reveal a complex intrinsic shower structure.

The results of the spectral analysis confirm our first correlation conclusion: in the 1986 observations, large-scale clouds of meteor dust simultaneously observable at the distant points were not found. The observed joint periods of 3.2, 2.3 and 2.0 minutes rather indicate smaller formations, such as groups of meteors ("bundles"). A high correlation in 1980 and 1982 in comparison with 1951 and 1986 shows that the Perseids produced many large-scale formations in the early 80s: "clouds" of about 0.5 to 1.5 Earth radii. Between "clouds" there were "gaps" of the same order of magnitude, where the shower's density is 2–3 times smaller than in the "clouds". We suppose the changes in the shower's structure during the parent body's encounter can account for this.

Since *IMO* can collect data from all over the world, it seems quite easy to carry out similar investigations using Perseid counts during 1-minute intervals on a basis Crimea-Bulgaria (or Hungary, Czechoslovakia, Yugoslavia)-Italy-Southern France, for instance. We would be very glad if *IMO* members could work on the Perseids in 1985, 1988, 1989, 1990 and 1991 (and also on the Geminids of 1982, 1983, 1985, 1987, 1989 and 1990) and communicate us their data.

In addition, it should be noted that the author will gladly accept any questions, remarks, comments etc., since this is the first time spectral analysis is used in meteor work.

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News from the USSR

A.I. Grishchenyuk

1. New meteor magazine

The G.O. Zateishchikov Meteor Station (All-Union Astronomical-Geodetical Society) and the Astronomical Observatory of the Young Technicians' Station have started distributing the All-Union magazine *Meteorny Vestnik* ("Meteor Herald").

The new magazine is published in Russian and also contains English abstracts for each item. Besides information from *WGN* and *IMO*, we publish various articles for the Soviet observers: meteor showers, catalogues and descriptions, methods of observations and data analysis. The Editorial Board is composed of V.V. Martynenko, V.M. Mozhzherin, A.S. Levina. The chief secretary is A.I. Grishchenyuk.

In the first issue, one can find an article by G.O. Ryabova (Tomsk) on the basic principles of meteor shower modeling, Paul Roggemans' outline of *IMO*, report on *IMO*'s *International Leonid Watch* program, I.S. Astapovitch's radiant catalogue for April–June (about 100 radiants), reviews of meteor articles from the "Astronomical Herald" (e.g., on fireballs over Crimea and Czechoslovakia, also reported in *WGN*), and Geminids' observational results from Crimea.

The second issue is expected to be devoted to the problems of observations and their processing.

At present, we have over 60 subscribers. We would appreciate if *IMO* members and amateur astronomers from Europe, America, Japan and Australia would participate in our magazine by submitting articles. If you can read Russian, you can send request to obtain the journal to V.V. Martynenko, whose address is mentioned in each *WGN* issue. We can also offer you an algorithm for gnomonic projection, which allows you to construct gnomonic meteor map with any desired center and/or scale by computer. For requests write to V.V. Martynenko.

Figure 1 – Front cover of the first issue of the *Meteorny Vestnik*.

2. AAGS Meeting

From April 1 to 3, 1991 the plenary meeting of the Central Committee of the *All-Union Astronomical-Geodetical Society (AAGS)* was conducted in Simferopol. There were astronomical and geodetical workshops that included reports of the AAGS members and lectures. During these activities, some Soviet *IMO* members (V.V. Martynenko, O.I. Bel'kovich, G.O. Ryabova, G.O. Andreev) and other meteor workers (A.I. Grishchenyuk, A.S. Levina, A.I. Poroshin, V.I. Tsvetkov, S.A. Maslenitsyn, and others) met and held a small discussion. Bel'kovich and Ryabova stayed in Simferopol for a week and participated in processing data from the Crimea Meteor Station archives. They succeeded in finishing the Geminid analysis over 20 years and made a lot of progress in the Perseid analysis. Information about the results will be published in *WGN*.

3. Meeting of USSR meteor amateurs in Kirov

A meeting of meteor amateurs from the USSR was held in Kirov from April 20 to 22, 1991. Unfortunately, the meeting was not very representative: apart from the hosts, there were only two teams from Crimea and one team each from four other sites. *IMO* member O.I. Bel'kovich (Kazan) attended the meeting. A discussion on the technique of observing and data processing was performed under A. Grishchenyuk's motto: "Different techniques must yield the same result". Besides the visual observations' project of the satellite for the investigation of the dust clouds in the Earth-Moon system, a program of radio (not radar) meteor observations was presented and a report on a meteorite impact were given. The latter report was presented by M. Kisilyov (Ufa) and is summarized below.

Figure 2 – From left to right: G.O. Ryabova, A.S. Levina, O.I. Bel'kovich, V.V. Martynenko, A.I. Grishchenyuk and V.I. Tsvetkov. Ryabova and Tsvetkov perform analysis on observations at the Crimea Meteor Station in Simferopol. (Photo by I. Salnikov)

The meteorite fell in the night of May 17-18, 1990 at 17^h20^m UT on the place with coordinates $\lambda = 55°35'$ and $\varphi = 53°36'$. An analysis of the visual observations showed that the meteorite traveled during 7–8 seconds from the South to the North under an angle of 45° with the horizon. One of the eyewitnesses at 1.5 km from the place of impact reported a "stationary" (point-like) meteor as bright as Venus during the first 5 seconds; then there was a blast and a short final flight. The radiant was determined to lie in Virgo.

As a result of the fall, an impact crater was formed with a diameter of 10 m and a depth of 4 m. It is surrounded by a rim of 60 cm high. In the first stage of examination of the impact area, small parts of the meteorite (800 grams in total) were collected. The meteorite turned out to be iron; laboratory studies labeled it as a middle-structure octahedrite. With the use of an excavator, two larger parts (over 3 kg and 6.6 kg, respectively) were digged out from a depth of 8–8.5 m. Features of the cut surfaces of these parts reveal that they broke apart when they were already in the ground. Crater features, the sizes of those two parts and the crater rim suggest that the size of the original body was 0.4 to 0.6 m in diameter, with a mass of more than 800 kg, and a penetration depth of 15–20 m.

4. Miscellanea

Recently some young Crimean amateurs were distinguished for their advances at several camps for school children—amateurs in science and technology. In Moscow, A. Dormidontov (Crimea) received a first degree diploma for a report on his investigations of Comet Levy. In Stavropol, V. Yaremchuk from Simferopol was distinguished for his advances in meteor astronomy.

Photographic Observational Results

A Photographic Geminid Campaign in Southern France

Casper ter Kuile, Peter Jenniskens, Marc de Lignie

An account is given of a photographic observing campaign for the 1990 Geminids, organized in Southern France by the Dutch Meteor Society.

1. Introduction

The 1990 display of the Geminid Meteor Stream promised to be one of the best in recent years: no disturbing moonlight and a maximum during the night, with the radiant high in the sky. Unfortunately, there is only a small chance of being able to observe Geminids in most parts of Western Europe due to abundant clouds in December. To escape bad observing conditions, many amateur astronomers before us have traveled to the Provence in the South of France.

In the summer of 1990, members of the *Dutch Meteor Society (DMS)* decided to organize a multi-station photographic campaign for the 1990 Geminids. From four sites (Le Thouron, Lardiers, Quinson and Cereste), meteor observing teams operated cameras in order to obtain multi-station Geminid photographic data, with overwhelming results. In this article, we describe our experiences in the Provence.

2. The observing site at Lardiers

Lardiers is a little village located about 42 km west of the city of Digne. It is located at a favorable distance of 54 km from Le Thouron and Quinson. Cereste is located about 30 km south of Lardiers. In Lardiers an international group of people stayed in a French "gîte". A "gîte" is a simple holiday accommodation, often situated in the countryside far from city lights, which is ideal for amateur astronomers. In Lardiers, we could even switch off the nearby street lights ourselves. Surrounding hills did not obscure the sky significantly; we had a complete unobstructed view of the southern part of the sky.

The following people stayed in Lardiers to see the 1990 Geminids: Evelyne Blomme and Paul Roggemans as visual observers, Malcolm Currie and Mark Vints as telescopic observers and Casper ter Kuile as a photographic observer.

What kind of equipment has been used?

A Canon T-70 with a 16-mm objective served as an all-sky camera. This camera can be programmed for unattended operation. In one observing night of 10 hours, this camera can take 30 pictures with an exposure time of 20 minutes each. Two 50-mm focal length Praktica cameras were pointed at an elevation of about 75° and were operated manually.

The so called "high altitude battery" consisted of 6 Zenit cameras with 58-mm Helios objectives. The cameras of this set were directed at an elevation of 55°. The "low altitude battery" consisted of 8 Prakticas equipped with 50-mm Oreston optics. The cameras on this construction were pointed at an elevation of 30°. The exposure time of all the SLR-cameras was approximately 25 minutes. All cameras were equipped with rotating shutters, yielding 25 breaks per second (if power was available ...), for velocity measurements.

Furthermore, we were able to use the photomultiplier equipment of Hans Betlem which is normally situated at DMS-Leiden. This equipment is capable of timing bright meteor events with an accuracy of better than one second. Meteors should be at least of magnitude -1 (in zenith) to be detected.

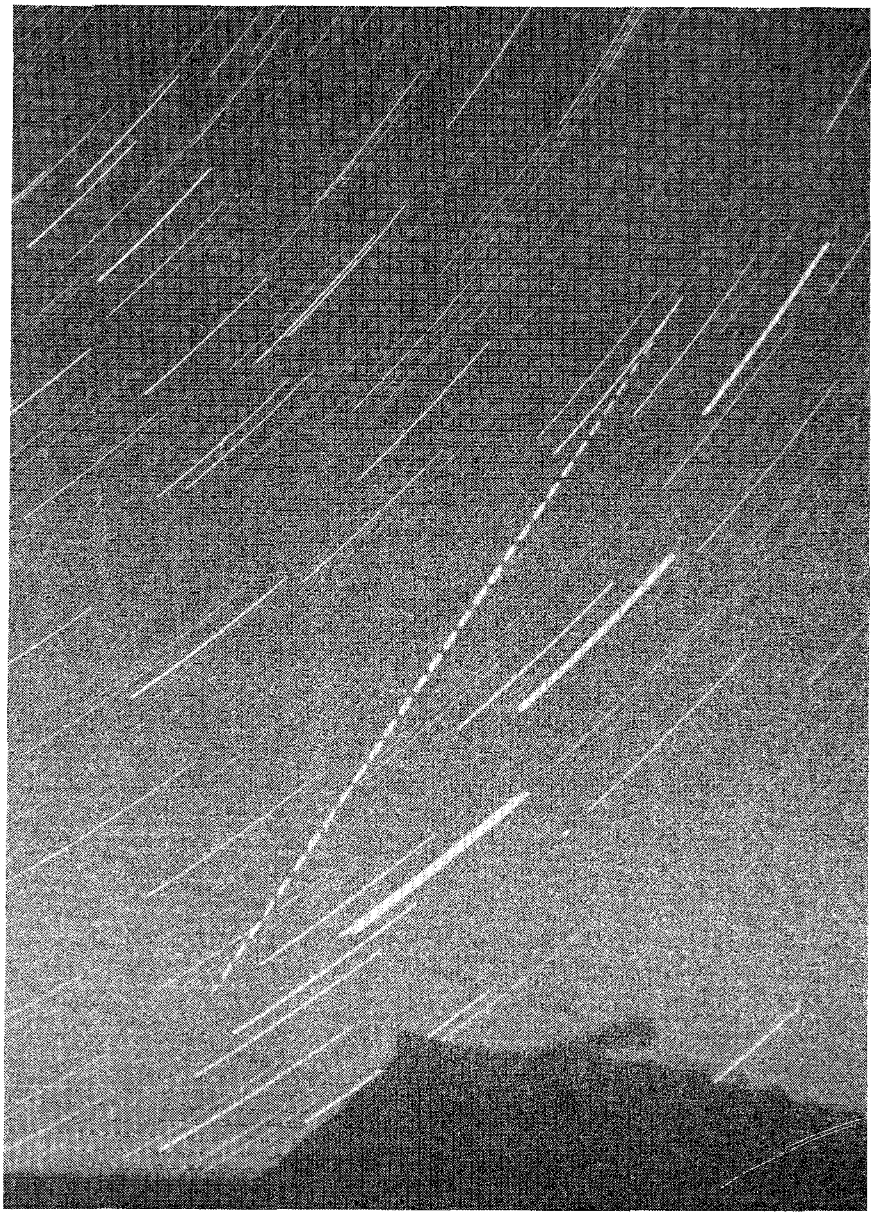

Figure 1 – A magnitude −3 Geminid in Ursa Major photographed in Lardiers on December 13, 23^h25^m UT.

3. The observing site at Le Thouron

Le Thouron is a small village about 15 km north of Barrême which consists of a small chapel and a few houses, located on the slope of a mountain. The location is at an altitude of about 1000 m, and the surrounding mountains allow a free view down to about 15° altitude. Only one street lamp interfered somewhat with the visual observations. In Le Thouron, Marc de Lignie and Peter Jenniskens stayed with a team of visual observers: Paul van der Veen, René Veldwijk and Mark Olie.

Marc operated a camera setup consisting of 6 cameras of type Praktica/Zenit equipped with 50-mm objectives, and 8 Lubitel cameras with 4.5/75 objectives which together covered the sky down to an altitude of 15°. Both setups were especially designed for the Geminid campaign. Some unsuccessful attempts were made to record meteors with an electrometer. Visual observations were done from a lawn in front of the "gîte" and from an observing place on the Col du Défends.

4. The site at Quinson

On the night of maximum activity, Peter Jenniskens used his car to travel to Quinson, a location forming an almost perfect equilateral triangle with Le Thouron and Lardiers. The location is on the edge of a forest, which eased the strong mistral winds somewhat, and only at about 500 m altitude, on the high plains. There were no problems with snow (like in Le Thouron) or fog (like in Cereste).

Peter operated a transportable set-up consisting of 6 small cameras of type Praktica/Zenit equipped with a 25-breaks/second rotating shutter and heating elements powered by a car battery, a design by Hildo Mostert. The cameras were pointed at an elevation of 60°, with one 28-mm wide-angle camera covering the zenith.

5. The site at Cereste

A German group of observers among which Bernhard Koch and Michael Nolle observed both visually and telescopically from Cereste. As part of the photographic project, Bernhard operated a Canon T-70 equipped with a 17-mm ultra-wide-angle lens pointed at the zenith.

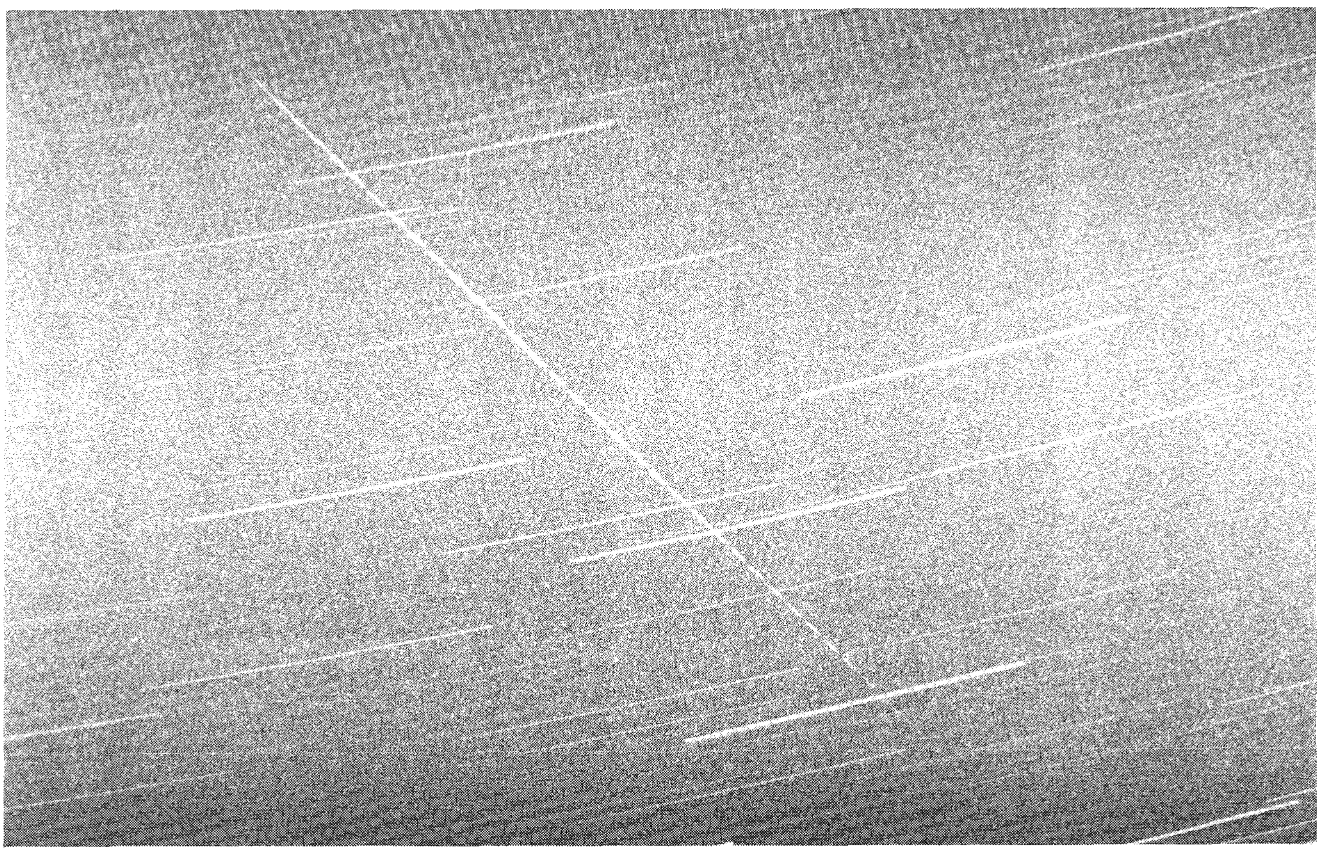

Figure 2 – A magnitude −3 Geminid in Lepus photographed in Lardiers on December 14, $22^h41^m43^s$ UT.

6. Some remarks concerning the photographic procedure

The rotating shutters use bicycle dynamos, a synchronous motor. The systems are as stable as the main's frequency, which is usually better than 1 in 500. All 1.8 and 2.0 optics are set at a diaphragm of 2.8, resulting in much sharper images on the negatives. The limiting magnitude for photographing meteors (about 0) will not get worse as result, because the light of the meteor is more sharply focused on the grains of the film. We use Kodak Tri-X (400 ASA black and white film) stored in cans containing 30 m of film. The film cassettes are filled with sections for 36 exposures (about 1.5 m). The administration of the films is very important. The cassettes are labeled according to the camera numbering. Afterwards, one can then easily find out which film belonged to which camera. The films were developed in Kodak T-max 400 developer for about 8 minutes at 25° C.

7. Weather and observing conditions

The campaign was planned to run from December 8 till 15. Unfortunately, the first nights were covered with clouds from a strong depression. Snow fell both at Le Thouron and Lardiers. The night of December 10-11 allowed about 2 hours of observations, both at Le Thouron and Lardiers, in the early evening. No bright meteors were seen.

From the night of December 11-12 onwards, skies were clear and very transparent. The mistral was strong at December 11-12 and 12-13. In both nights, this resulted in a power failure that prevented us from using the rotating shutters. Fortunately, we had no such problems during the succeeding nights of December 13-14 and 14-15.

One has to acknowledge the transparency of the sky in Southern France. It is really overwhelming to see Puppis low above the southern sky. Orion is an impressive display. Often we saw meteors disappear behind distant hills. Sometimes, they even seemed to fall right into the Mediterranean; only the splash was missing! The limiting magnitude is not that much better than at dark places in Holland. The real difference is the superb dark background. The Milky Way, Sirius and Mars are really disturbing light sources. The Zodiacal Light is obviously present. Magnificent!

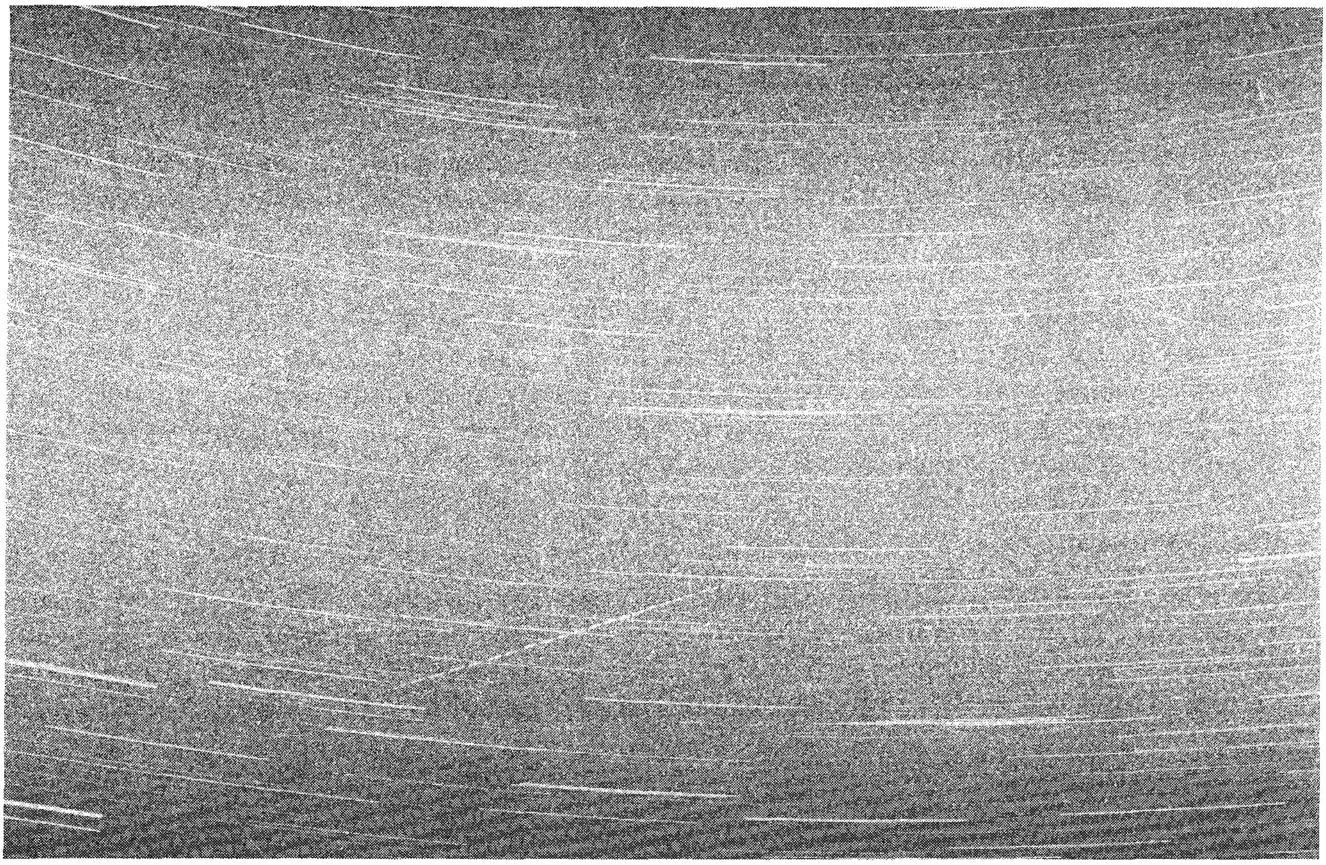

Figure 3 – A pair of Geminids in Cancer, photographed from Lardiers on December 14, 1990. The brighter one is of magnitude −2 and appeared at 3^h18^m UT.

8. First results

In total, about 100 films were exposed, amounting to 40 hours of exposure per camera with 17 + 14 + 6 + 1 cameras. The numbers of meteors recorded is overwhelming indeed. Cereste recorded 5 meteors on film, Quinson recorded 150. Le Thouron even 250 and at Lardiers some

350 meteors were recorded photographically. Obviously, over 100 multi-station events are among those. How the meteors were distributed over the nights is shown in Table 1 (Lardiers results).

Table 1 – Distribution of photographed meteors at Lardiers.

Night	Meteors	Tot. exp. time	Eff. exp. time	Exposures
Dec 11-12	7	09^h14^m	08^h54^m	20
Dec 12-13	11	09^h14^m	09^h01^m	22
Dec 13-14	232	11^h18^m	10^h56^m	28
Dec 14-15	98	08^h43^m	08^h27^m	20
Total	348	38^h29^m	37^h18^m	90

9. Reduction of the data

To indicate the abundance of these data, it should be noted that the Dutch Meteor Society in all of its existence, now 11 years, has obtained and reduced some 150 multi-station events. The results have been published in *Radiant*, the Society's journal. We spent a lot of time to organize the campaign and to get the photographic equipment in perfect condition. But none of us realized that such a tremendous amount of meteors could be photographed under the dark skies of the Provence!

This became really clear to us when searching for meteors on the many negatives. On some negatives as much as four meteors could be identified. A big amount of time has been spend on determining the begin and end point of the meteor trail on the negative. Joining visual observing timings to meteors on the negative as well as other administration tasks costed many hours of work.

To appreciate the time involved in reducing these data, one should note that for reducing one negative of a multi-station set, about half an hour of time is required for printing and identifying the stars in the field, and another hour to measure the positions on the Jena astro-record measuring device at the Leiden Observatory. The reduction of all the Geminid data is therefore a major project and only feasible because we have three enthusiastic teams, led by Hans Betlem, who do the actual measurements on a weekly basis.

10. Conclusion

The 1990 photographic Geminid campaign has been very successful. This is a strong argument to organize similar events in the future. In view of the forthcoming Leonid storm, observations of this stream in the preceding years are necessary, for instance. But beware: watch your mental strength before you start a campaign like this one. It costed us many evenings and weekends!

Acknowledgments

We are grateful to the following persons: Paul Roggemans for inviting us to stay at Lardiers, Bernhard Koch for his enthusiastic help with the operating of the Canon camera, Hans Betlem and Hildo Mostert for their assistance in building the equipment needed and providing the photomultiplier set-up, and the DMS observers who were not able to join but gave us strong mental support.

Reference

[1] Jenniskens P., ter Kuile C.R., de Lignie M., "Geminiden 1990 in Zuid-Frankrijk", *Radiant* 13, 1990, p. 8.

Radio Observational Results

The January 22–23 Mystery Solved?

Erwin van Ballegoy

The enhanced radio meteor activity observed by Dirk Artoos and others in 1989 and 1990 around January 22–23 [1,2] could be confirmed by the author in 1991.

For two years in a row, Dirk Artoos observed an increased radio meteor activity around January 22–23 [1,2].

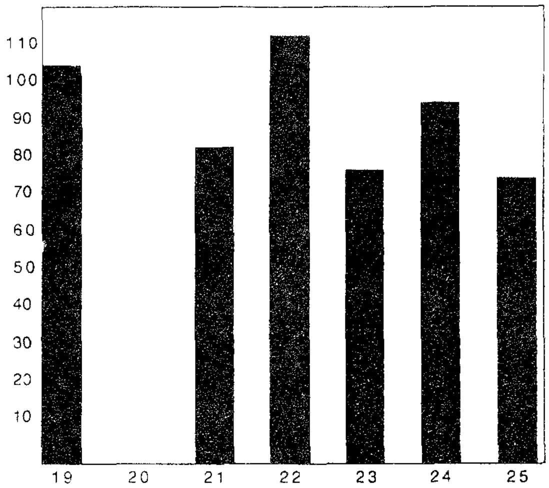

Figure 1 – Radio observations by the author in Nijmegen, the Netherlands during January 1991.

I tried to establish whether this was due to a fluctuation in the sporadic background, or indeed a new stream. Therefore, I observed in 1991 between January 19 and 25, from 10^h to 11^h UT, as suggested by Dirk Artoos [2], at an azimuth of 0° and an elevation of 45°. The frequency used was 107.5 MHz. Gotfred M. Kristensen observed under comparable conditions in 1989 ($A = 0°$, $h = 35°$, $f = 100.50$ MHz) [1].

Although Gotfred observed a highly increased activity on January 22, 1989, I could only observe a slight increase in activity on January 22, 1991.

But if one takes into account that there was also an increase in activity on January 22, 1989, and on January 23, 1990, this can hardly be a coincidence anymore. It starts to look like there is a minor stream active around that date. To establish this more convincingly, future observations remain necessary.

References

[1] Van Wassenhove J., "Unusual Meteor Activity in January 1988", *WGN* 17:6, December 1989, pp. 214–215.

[2] Artoos D., "An Unsolved January 22–23 Mystery", *WGN* 18:6, December 1990, pp. 209–210.

I think it is necessary to warn observers not to jump to conclusions too easily. Although the author did observe some increase on January 22, one can wonder whether this increase is statistically significant, especially since the author's count on January 19 is almost as high. (Ed.)

May 1991 Radio Results

Dirk Artoos

An account is given of the author's radio observations during the month of May, 1991

During the month of May 1991 I have observed each day from May 1 to 25, always from 7^h40^m to 8^h15^m UT. It was a very interesting period to follow the evolution of the daylight activity. As you can see in Figure 1, there was the η-Aquarid activity with a maximum on May 3. There was also a second maximum on May 2. In my personal opinion, this may have been caused by Halley 530 ($r = 0.001$ AU). The third maximum around May 8 is likely the result of Halley 1910 ($r = 0.06AU$) [1]. The entire period May 1–8 is dominated by the η-Aquarids.

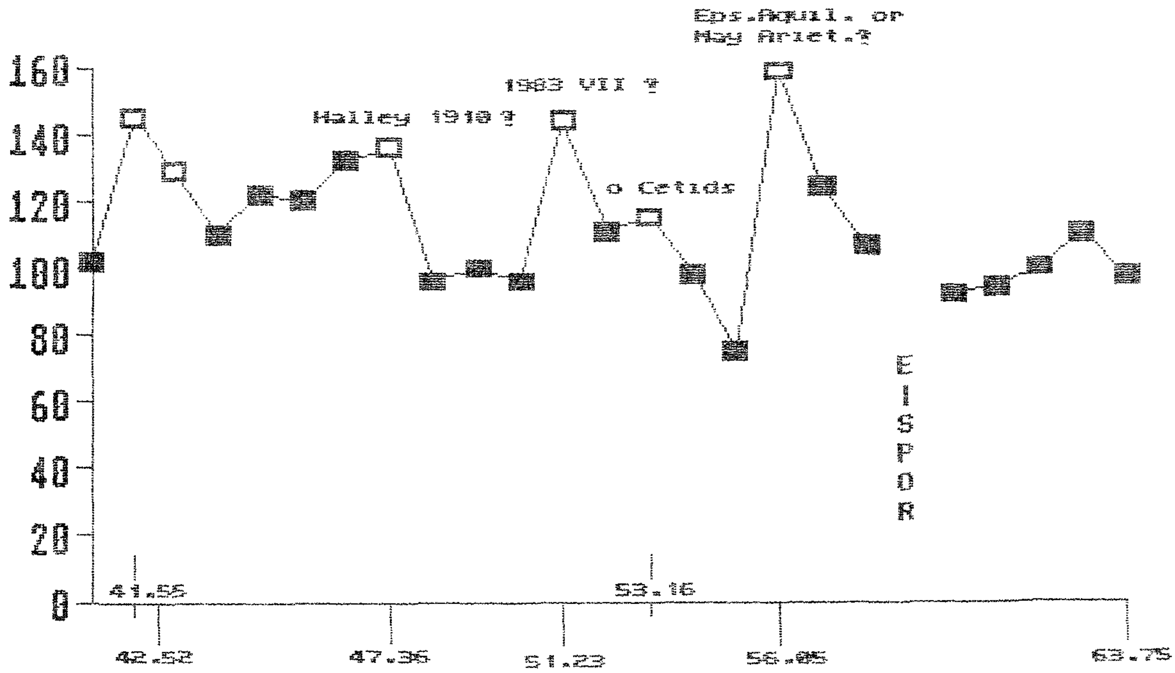

Figure 1 – Meteor counts by the author in May 1991, each day between 7^h40^m and 8^h15^m UT. Solar longitudes refer to eq. 2000.0.

A few days later, on May 12, a high peak occurs, probably the result of Comet 1989 VII P/Iras-Araki-Alcock. The associated theoretical radiant was mentioned in [2]. A slight increase two days later is probably due to the o-Cetids. This radiant also produces a daylight shower with an average position near maximum at $\alpha = 28°$ and $\delta = -03°$. They were first detected on May 14, 1950, by radio. It is a shower with low activity levels and until now, no association with a comet or asteroid has been established.

The following days, the echo activity dropped to the background level, to make a jump on May 17–18 towards the greatest activity of the month, caused by the ε-Aquilids or the May Arietids. According to several publications [3,4], the predicted maximum of the May Arietids is May 16, and that of the ε-Aquilids, who are only detectable by optical or radio equipment, is May 17. The responsible body for this latter radiant is probably an asteroid of the Aten class. I think that the increase in number of radio reflections is due to the combination of both showers. Unfortunately, it is not possible with my equipment to distinguish both showers.

As a general conclusion, the fifth month of 1991 turned out to be very fruitful with several major and minor radiants active.

References

[1] Jack D. Drummond, "Earth-Orbit-Approaching Comets and Their Theoretical Meteor Radiants", 1981.

[2] J. Wood, R. Koschack, "Visual Observers' Notes: May and June 1991", *WGN* 19:2, April 1991, p. 37.

[3] G.W. Kronk, "Meteor Showers: a Descriptive Catalog", Enslow, 1988, pp. 94–99.

[4] A.C.B. Lovell, "Meteor Astronomy", 1954.

Bright Radio Lyrids in 1990 and 1991

Gotfred Møbjerg Kristensen

While continuous radio registrations show only a weak increase with respect to the background level for the global activity of the 1990 and 1991 Lyrids, similar profiles for bright radio Lyrids show a distinct, very sharp and narrow peak instead that can be easily missed when observing visually.

If you look on the total numbers of Lyrids observed by radio on a 24 hour per day basis with a pen-recorder seen in 1990 and 1991, you will only see a weak increase in activity around April 22 against the background activity in April (not illustrated here).

However, Figures 1 and 2 in which only bright radio Lyrids are included, show a different picture. There is a very distinct peak around April 22, 1990 and around April 21, 1991, if you only look at radio meteors with a duration over 8 seconds.

In 1990, most of the bright radio meteors appeared within an interval of 2–3 hours on April 22. Maybe, so narrow a maximum can be easily missed by visual meteor observers.

During my observations of radio meteors by pen-recorder, I sometimes register a short-duration outburst of signals. The number of radio meteors rapidly increases to high activity within a few minutes and decreases a little later back to the normal background level. On April 6, for instance, the number of radio meteors rose to 155 between 2^h and 3^h UT. In the hours before and after, the number was not higher than 51. Also, the days around April 6 showed stable activity. I could not notice any changes in the observing conditions.

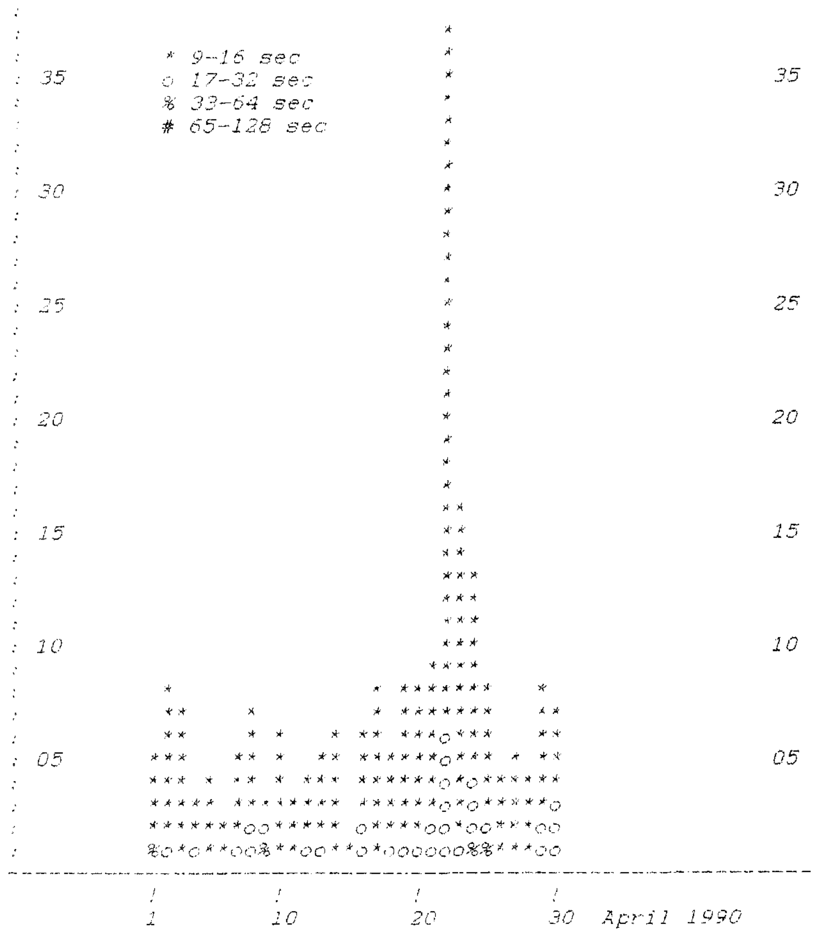

Figure 1 – Bright radio meteor registrations by the author during April 1990.

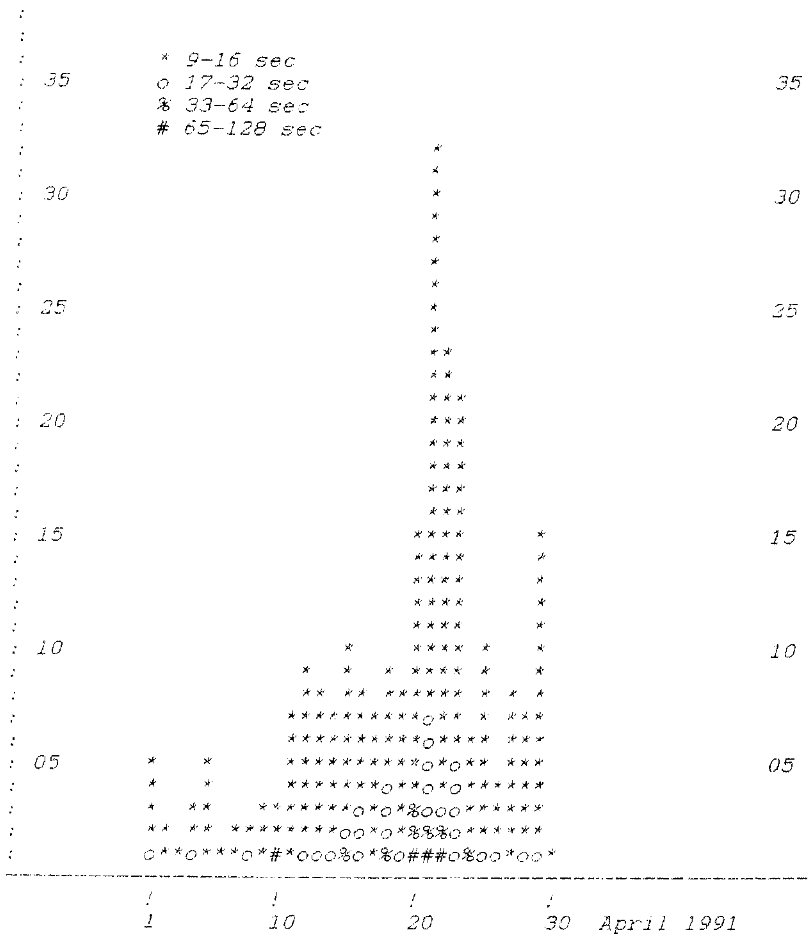

Figure 2 – Bright radio meteor registrations by the author during April 1991.

Visual Observational Results

JAS Meteor Section 1990 Leonid and Geminid Results

Alastair McBeath

An examination of the UK visual results for the 1990 Leonids and Geminids is presented. Normal maximum activity seem to have occurred for both showers.

1. Introduction

November's weather favored almost the whole Leonid epoch in 1990 for the first time in many years as seen by the *JAS Meteor Section* and to the surprise of many people, less than a month later the Geminid peak also enjoyed clear skies. Eleven observers contributed 85.7 hours of meteor watching in November and December, spotting 1307 meteors (39 Taurids, 35 Leonids, 756 Geminids and 477 sporadics). The observers were:

> Neil Bone, Shelagh Godwin, Craig Johnson, Richard Livingstone, David Lloyd, Lee Macdonald, Tony Markham, Alastair McBeath, Steve Phipps, Graham Pointer, Ian Rigney.

Analyses were carried out to determine magnitude distributions, meteor activities and train proportions from all the above sources when the limiting magnitude was +5.5 or better and the cloud cover less than 20%. The mean limiting magnitude was +6.1 in November and +5.8 in December. Magnitude and train results are shown in Table 1.

Table 1 – Global magnitude distributions and train percentages (%) for JAS Meteor Section UK observers in November and December 1990.

Shower	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	$\overline{m}$	$\overline{m}_{6.5}$	%
Taurids	2	1	1	1	5	10	8	8	0	36	1.9	2.3	8
Leonids	0	2	3	6	6	4	4	3	0	28	1.1	1.5	75
Spor. (Nov)	1	2	2	10	20	35	76	29	19	194	2.7	3.1	8
Geminids	14	27	36	83	135	158	151	90	22	716	1.7	2.4	5
Spor. (Dec)	4	0	10	22	41	59	57	20	10	223	1.9	2.7	7

ZHR data is given in the section below for each shower. Corrected sporadic mean HRs were 12.4 ± 0.9 and 10.7 ± 0.8 for November and December respectively.

2. Taurids

Conditions prevented anything of their peak rates from being seen, though combined ZHRs of up to around 10.5 ± 4.0 were recorded on November 14-15, which were higher than those obtained subsequently ($\sim 6 \pm 4$ and $\sim 5.5 \pm 3.0$ on November 17-18 and 18-19 respectively). Too few were seen for the magnitude analysis to have any real weight.

3. Leonids

Again the low numbers make the magnitude distribution unsound, but the shower received more coverage than has been possible for many years. Mean ZHRs from four nights are given in Table 2.

Table 2 – 1990 Leonid mean ZHRs.

Date	ZHR
Nov 14-15	5.3 ± 3.7
Nov 17-18	7.1 ± 3.6
Nov 18-19	3.1 ± 2.2
Nov 19-20	2.7 ± 1.9

November 17-18 produced the highest activity, although the true peak was probably missed. No obvious sign of an unusual high return was apparent in these results however.

4. Geminids

Significant Geminid results were obtained on only two nights in December, covering the maximum and part of its decline. The mean ZHR from December 13-14 was about 85 ± 14 overall, but activity appeared highest between 1^h and 3^h UT, when the mean ZHR reached circa 96 ± 13, roughly normal from the recent returns. On December 14-15, the mean ZHR had dropped to around 22 ± 6, though it was clearly falling throughout that night.

The large number of meteors from the shower at this epoch gives the magnitude distribution a reasonable credibility. The corrected mean magnitude indicates that r for the stream was about 2.2. This is a somewhat higher figure than might have been expected, but was almost certainly due to the effects of mass-sorting of the stream's particles noted by other workers previously, a consequence of almost 88% of all the Geminids reported occurring near the maximum on December 13-14.

One problem that several people commented on from the peak night was the great difficulty in keeping pace with the observed meteor rates, which at times reached four or five events per minute. This is a question which has wider implications for the more active showers and particularly for meteor storms. While the higher visual rates provide a marvelous spectacle for the observer, meaningful results are still needed from such occurrences, and a discussion on this topic leading to some *IMO* guidelines on what to record under these circumstances would perhaps be generally welcomed.

5. Conclusions

After an essentially disappointing year, the latter stages of 1990 provided a pleasing break, with the Geminid peak being especially well-seen for once. The Leonids too received more attention than for some years and both streams showed no unexpected characteristics from this data.

Acknowledgment

I am always indebted to the contributing observers for all their time and effort summarized in this report.

The 1990 Lyrids in Australia

Jeff Wood

An account is given of the 1990 Lyrids as seen in Australia. A normal activity was registered.

Members of the *NAPO Meteor Section* carried out a series of observations of this northern hemisphere shower from April 19 to 24. A total of 15 man hours of observations were made on five nights by two observers, Mark Glossop and Jeff Wood. Their results indicate that the Lyrids produced a normal display in 1990 with a maximum ZHR of 12 being recorded on the night of April 21-22.

Table 1 – 1990 Lyrid activity as seen in Australia.

Date	Mean ZHR	Nr. Obs.
Apr 19-20	1.9 ± 0.6	3
Apr 20-21	7.5 ± 1.5	3
Apr 21-22	12.5 ± 1.2	3
Apr 22-23	1.5 ± 0.6	3
Apr 23-24	0.4 ± 0.6	3

Table 2 – Magnitude distribution of the 1990 Lyrids in Australia

Magnitude	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$
Number	1	4	16	21	15	5	62	2.97

The ratio of the increase in the numbers of Lyrid meteors per magnitude calculated using the correction factors derived by Kresakova (1966) is 3.01 for the magnitude range in Table 2.

Of the 21 Lyrids of magnitude +2 or brighter, 5 were blue, 2 yellow and 14 were white in color. Few of the 1990 Lyrids had a train. Only 8% of those seen produced a train.

The 1990 Grigg-Skjellerupids in Australia

Jeff Wood

An account is given of the 1990 Grigg-Skjellerupids, also called π-Puppids, as seen from Australia. A low but detectable activity was registered.

This shower which is also known as the π-Puppids, is a periodic one with good rates only being seen the years the parent comet P/Grigg-Skjellerup reaches perihelion. The last such time was in 1987 and so *NAPO Meteor Section* observers were not expecting much activity in 1990. Nonetheless, the unexpected can happen and so 22 man hours of watches were carried out by Mark Glossop, George Platt, Adam Marsh and Jeff Wood from April 17 to 24. Their data indicated low but detectable Grigg-Skjellerupid activity between April 21 and 24. The maximum ZHR recorded was 1 per hour on the evening of April 22-23. The Grigg-Skjellerupids seen were yellow-orange in color and quite bright as is evidenced by their average magnitude of 1.71. None of the Grigg-Skjellerupids seen had a train despite the brightest meteor having a magnitude of −2.

The 1990 η-Aquarids in Australia

Jeff Wood

An account is given of the 1990 η-Aquarids as seen in Australia.

The η-Aquarids are one of the major meteor showers of the southern hemisphere. In 1990, the *NAPO Meteor Section* once again carried out an extensive set of observations of this shower. Beginning on April 20 and ending on the morning of May 7 when the Moon and poor weather prevented further observations, 15 observers watched over 12 nights obtaining 84 man hours of data. The participating observers were as follows:

Jeff Wood, Adam Marsh, Mark Glossop, George Platt, Michael Keating, Derek Fernandos, Guy Blackman, Huon Chandler, Martin Coroneos, John Drummond, Martin Sale, Nigel McKillen, Stephen Kerr, Geoff Carstairs and Andre Moore.

Table 1 – 1990 η-Aquarid activity as seen in Australia.

Date	Mean ZHR	Nr. Obs.	Date	Mean ZHR	Nr. Obs.
Apr 20-21	0.3 ± 0.4	3	May 01-02	20.2 ± 1.1	4
Apr 21-22	0.3 ± 0.4	3	May 02-03	22.5 ± 1.7	4
Apr 22-23	0.9 ± 0.7	3	May 03-04	31.0 ± 2.2	10
Apr 23-24	0.5 ± 0.5	2	May 04-05	45.0 ± 5.4	13
Apr 28-29	7.6 ± 0.1	2	May 05-06	46.9 ± 5.2	6
Apr 30-31	9.6 ± 1.5	7	May 06-07	31.8 ± 4.4	2

Table 2 – Magnitude distribution of the 1990 η-Aquarids in Australia.

Magnitude	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	Tot
Number	3	4	4	16	19	32	85	185	257	217	79	9	910

The average magnitude of the η-Aquarids seen was 2.69. The ratio of the increase in the numbers of η-Aquarid meteors per magnitude calculated using the correction factors described by Kresakova (1966) is 2.59 for the magnitude range from -1 to $+5$.

The color distribution of 348 η-Aquarid meteors of magnitude +2 or brighter is as follows :

39.08% yellow, 5.46% blue, 7.18% orange, 2.01% green, 0.29% violet, 0.86% red and 45.12% white.

27% of the η-Aquarids seen had a train. A feature of these trains was their longevity. Several lasted for more than 20 seconds after the meteor itself disappeared from view. The most persistent of these was one that was produced from a magnificent yellow magnitude -4 fireball. These trains persisted for 90 seconds and noticeably distorted and drifted in a south-easterly direction under the guidance of the upper atmosphere winds.

The 1990 η-Aquarids in Southern Brazil

Gilberto Klar Renner

An overview is given of the 1990 η-Aquarids as seen in Southern Brazil.

We present results on the 1990 η-Aquarids realized by observers of Porto Alegre, in the state Rio Grande do Sul, in Southern Brazil. The observers were:

Clarice Azevedo Machado, Darlain Morais, Gilberto Klar Renner, Luís Antonio Reck de Araújo, Luís Antônio da Silva Machado, Luiz Augusto Leitão da Silva and Onofre Dácio Dalávia.

The r-value obtained from 312 η-Aquarids is 2.4, in accordance with [1]. A magnitude distribution is shown in Table 1.

Table 1 – Magnitude distribution of the 1990 η-Aquarids and the sporadic background in S. Brazil.

Magnitude	−1	0	+1	+2	+3	+4	+5	Tot	$\overline{m}$
η-Aquarids	1	12	40	77	97	77	8	312	+2.66
Sporadics	4	13	31	92	110	86	30	367	+2.82

[1] J. Wood, "The 1989 η-Aquarids in Australia", *WGN* 18:3, June 1990, p. 65.

The 1989 α-Scorpids in Spain, Uruguay and Bolivia

José M. Trigo

This article refers to observations of the α-Scorpids made by the members and collaborators of the Spanish Meteor Society in 1989. A main maximum was found on May 5-6.

During 1989, the number of observations of this shower was high; a moderate activity level was found. This article analyzes the results of a total of 33 observers in 1989. Their names were as follows:

Rafael Barragán, Luís R. Bellot, Javier Caballero, José Cáceres, Raúl Cagigao, Diego Cancela, Alejandro Castillos, Oscar Cervera, Carmen Darias, José V. Díaz, Antonio Francisco, Blanca García, Pedro García, R. García, Carlos González, Fabiola Gonzalez, Jorge

González, Oswaldo González, Natalie Guillén, Mark Kidger, Paula Kolenc, Bernardo Landro, Rubén López, Gustavo Mastoros, José Moisés, Rosario Moyano, Francisco Narros, Marcelo Núñez, Andrés R. Paños, Francisco Reyes, Iván Romero, Miguel Sanz, José M. Trigo.

During 10 nights, over 30 individual ZHR values were obtained. These ZHR values were grouped in 4-hour intervals. The results are shown in Table 1.

Table 1 – ZHR values for the 1989 α-Scorpids in Spain, Uruguay and Bolivia.

Date	$\lambda_\odot$	Nr. Obs.	α-Sco	ZHR
Apr 26-27	36°55	1	1	2.0 ± 1.5
Apr 28-29	38°20	13	21	5.6 ± 3.0
Apr 30-31	40°40	1	1	1.3 ± 1.0
May 03-04	43°30	2	5	3.8 ± 1.9
May 05-06	45°05	13	8	6.8 ± 3.3
May 05-06	45°25	4	2	1.5 ± 1.1
May 06-07	46°25	5	8	3.1 ± 1.7
May 07-08	47°20	4	4	1.4 ± 1.1
May 09-10	49°15	2	2	3.2 ± 1.8
May 10-11	50°15	2	2	2.2 ± 1.6

We also studied the increase of activity. Oscar Cervera Garcia registered a ZHR of 10.8 ± 4.2. During that night the activity was high, but only for a short period. Unfortunately the observations were not continued long enough, whence the results are not very decisive. To obtain the individual ZHR values, a population index of 2.00 was assumed; the value calculated from 39 meteors between -1 and $+4$ is 2.10 ± 0.38. The magnitude distribution of the 1989 α-Scorpids observed Spain is shown in Table 2. The average magnitude is 2.13 (or 2.73, after correction for the limiting magnitude).

Table 2 – Magnitude of the 1989 α-Scorpids in Spain.

Magnitude	−3	−2	−1	0	+1	+2	+3	+4	+5	Tot
Number	1	1	2	3	4	7	12	9	0	39

The June Lyrids in Spain and Bolivia

José M. Trigo

During June, several members of the Spanish Meteor Society organized intensive watches in the years 1987, 1988 and 1990. A maximum activity was found at $\lambda_\odot = 84°50$ with a ZHR of 5.

During the last years, only few references were made to this radiant. In this article, we would like to contribute a little to the general knowledge about this stream. The stream's activity seems to coincide with the dates mentioned by Paul Roggemans in [1], although our observations indicate still some activity of this stream on June 24, 1990. The observing sessions were held in Spain—Valencia and the Canary Islands—and in Bolivia—Cochabamba. The following observers took part in the campaigns:

Javier Alonso, José Antonio Cáceres, Oscar Cervera, José V. Díaz, Victor González, Raul Fernández, Antonio Francisco, Victor González, Juan Hernández, David Hernández, Mark Kidger, Rosario Moyano, Andrés R. Paños, Vicente Soldevila, José M. Trigo, Dulce Plasencia and Daniel Verde.

During these three years, 17 people participated totaling 71 hours of observing time. A total number of 61 June Lyrids was recorded. Over 25 individual ZHR values were obtained. These ZHR values were grouped in 4- to 6-hours intervals, averaged and the standard deviation calculated. For all observations, the plotting method was used. The center of the field of view was chosen in the proximity of Lyra. The results are shown in Table 1.

Table 1 – ZHR values for the June Lyrids in Spain and Bolivia.

Date	$\lambda_\odot$	Nr. Obs.	Lyr (Jun)	ZHR
1988 Jun 11-12	$80.^\circ37$	2	11	1.4 ± 0.5
1987 Jun 13-14	$81.^\circ59$	1	2	2.2 ± 1.3
1987 Jun 14-15	$82.^\circ48$	2	1	2.7 ± 2.0
1987 Jun 15-16	$83.^\circ43$	3	5	5.9 ± 2.3
1987 Jun 16-17	$84.^\circ40$	2	2	4.7 ± 3.4
1990 Jun 16-17	$84.^\circ74$	6	25	3.1 ± 1.1
1987 Jun 20-21	$88.^\circ38$	4	7	1.2 ± 0.6
1990 Jun 23-24	$91.^\circ53$	4	8	0.7 ± 0.3
1987 Jun 24-25	$92.^\circ26$	2	0	0

The activity is highest in the nights of June 15–17 but generally differentiates very poorly from the background activity. The magnitude distribution of the June Lyrids observed is shown in Table 2.

Table 2 – Magnitude distribution of the June Lyrids in Spain and Bolivia.

Magnitude	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
Number	1	2	2	7.5	11.5	20.5	15	1.5	61	3.55

The poor activity of the June Lyrids necessitates to combine observations to obtain population index values. The r-value obtained (for 59.5 meteors) is 2.92 ± 0.36, but on June 17, at $\lambda_\odot = 84.^\circ40$ (year 1990), a value of 3.13 ± 0.41 was obtained.

In the future, we hope to organize an extensive *IMO* campaign, with the aim of getting more reliable results. In Spain, our society will devote special attention to the June Lyrids in the coming years.

[1] P. Roggemans, ed., "IMO Handbook for Visual Meteor Observations", Sky Publishing Co., Cambridge, Mass., 1989.

New Minor Shower in June?

José M. Trigo

During observing campaigns for the June Lyrids in 1988 and 1990, members of the Spanish Meteor Society and collaborators of the "Agrupación Astronómica" of Tenerife registered activity from a radiant near λ Aquilae.

Only a few references to the detected radiant exist, yet its activity is mentioned in the work of the NAPO Meteor Section in Australia [1]. In their shower list, the radiant is mentioned under number 90 as the λ-Aquilids, with coordinates $\alpha = 288^\circ$ and $\delta = -05^\circ$. The activity period given is June 9–18.

During observations of the June Lyrids carried out by Spanish observers in 1988 and 1990, a very high percentage of meteors radiated from this region in the sky (e.g., 19 out of 122 meteors on June 17, 1990, or 15%). We tried to identify the λ-Aquilids very conscientiously, in order to avoid the grave consequences of including the high sporadic and Scorpid/Sagittarid activity. The method applied by the author and Mark Kidger (*Instituto de Astrofísica* of the Canary Islands) is explained in [2]. The visual characteristics of this radiant are very important for distinguishing these meteors.

During 1988, activity from this radiant was detected by the author and Vicente Soldevila in the night of June 11-12, but this activity was really low. In 1990, however, the author received observations from the Canaries which give evidence supporting the existence of the shower. The ZHR obtained by this group on June 17, 1990 is only 3–4, but the relative activity is 0.15! Activity of the radiant was also registered on June 24, 1990 but the ZHR then was very small; the relative activity during that night was only 0.04. The observers were:

Javier Alonso, José Antonio Cáceres, David Hernández, Daniel Verde, Victor Gonzáles, Dulce Plasencia and Mark Kidger.

The velocity of the meteors was moderate and the magnitude distribution of the λ-Aquilids observed in 1988 and 1990 is as in Table 2 (average limiting magnitude of +6.5).

Table 1 – Magnitude distribution of the λ-Aquilids in Spain.

Magnitude	−1	0	+1	+2	+3	+4	+5	+6	Tot	$\overline{m}$
Number	2	0	4	5	4	9	4	0	28	2.85

The radiant positions obtained from the visual observations were as in Table 3. In three radar studies conducted during the 1960s [3], the data obtained supports this stream's existence (see Table 4). Sekanina indicated a maximum of the shower on June 17.5 during 1969!

Table 2 – λ-Aquilid radiant positions obtained from visual observations in Spain.

Date (UT)	α	δ	λ-Aql	Remarks
1988 June 11	282°	−05°	4	1 stationary
1990 June 17	295°	−02°	19	

Table 3 – λ-Aquilid radiant positions obtained from radar observations [3].

Period	α	δ	λ-Aql	Author(s)
1961 June 13–19	293°9	−08°4	4	Nilsson
1969 June	289°	−06°	13	Gartrell, Elford
1969 June 2–July 2	297°1	−07°1	35	Sekanina

In our opinion, our data would justify an inclusion of the shower in the *IMO* list. We ask all visual and radio observers to monitor this possible minor shower in future years.

References

[1] NAPOMS, "A list of southern hemisphere meteor streams prepared from observations made over the period 1970–81".

[2] J.M. Trigo, "The ε-Perseids in 1987 and 1988", *WGN* 17:4, August 1989, pp. 156–158.

[3] G.W. Kronk, "Meteor Showers: A Descriptive Catalog", Enslow Pub., 1988.

British Astronomical Association Meeting

Edinburgh, Scotland, May 4, 1991

Alastair McBeath

The meeting, the first of its kind to be held in Britain since June 1985, opened at 10^h30^m a.m. at the Calton Hill Observatory with a brief address of welcome by the President of the hosting Astronomical Society of Edinburgh, Dr. Dave Gavine, who introduced George Spalding, the BAA Meteor Section (BAAMS) Director, chairman for the first session. After discussing the day's arrangements and quickly outlining the overall BAAMS structure, George introduced the first speaker, Dr. Colin Steele, the BAAMS Network Coordinator.

Colin described the area of the Northern Network, which covers all of Scotland and Northern England down to the Lake District and North Yorkshire, and then ran through the basic visual observing procedure used by most meteor watchers in this area. He went on to talk about the main showers observers in the region have enjoyed some success for, using as a particular example the 1983 Perseids, as well as those which are very difficult to detect from Britain, such as the ι- and δ-Aquarids. He concluded by mentioning the photographic work which has also been carried out in recent years.

Following a short break for refreshments and informal meetings with friends old and new, Colin Steele took the chair and introduced Alastair McBeath, Vice-President of the *IMO*. Alastair gave details on the *IMO*, its aims, some of its publications and its six Commissions, and presented both theoretical and practical reasons why global meteor observing is very important to our understanding of the meteor activity the Earth encounters. He urged all interested meteor workers to join the *IMO* and participate in its activities.

Colin then asked Neil Bone to speak on BAAMS observations of the Taurids from 1981 to 1988. Neil led into an overview of the Taurid results by noting the historical sightings of the shower and its links with Comet P/Encke. Combined results from the eight years totaled 1657 Taurids in 1060 observing hours, with overall activity seen between October 15 and December 1, and a flat maximum of some 10–15 meteors per hour apparent between roughly November 3–9. Neil mentioned that, contrary to expectations, the northern branch of the shower seemed the more active and very few really bright events were recorded. The mean magnitude was +2.4 and 10% were trained, both figures similar to the sporadics for the same period.

Lunch and an opportunity for further discussions came after this talk, and then the afternoon session began, chaired by Dr. John Mason, BAAMS Assistant Director. The first speaker was Dr. David Hughes, a professional astronomer from Sheffield University, who has made considerable use of amateur meteor data in his recent work. His lively presentation was on meteor streams both large and small and how they change with time. We were treated to some fascinating discussion of the Quadrantids, Perseids and Geminids, as well as the Orionids, Andromedids and Leonids, and learned that Mars is actually better-placed than the Earth to observe meteor showers, while at Jupiter the Galileo probe should be able to make observations of meteors in the Jovian atmosphere! Many minor showers probably exist, Dr. Hughes said, but with rates at best below three meteors per hour, were quite undetectable above the sporadic background using visual observations. He also commented that the Leonids are only as impressive in their periodic storms because of their high velocity. If slower, they would produce meteors too faint to be seen. As the prolonged applause showed, this was the best-received talk of the day.

Next, Tony Markham, Meteor Correspondent for *The Astronomer* magazine, took an amusing look at how easy it can be to "discover" a new but totally fictitious shower, and went on to examine various lists of meteor streams to try to answer the question "Which meteor showers exist?". His conclusion was that more observations, using all techniques, are necessary to help us find out.

Dr. Dave Gavine then presented some extremely interesting information he has recently discovered on observations of the 1799 Leonid storm made from America, Germany and the UK. One Scottish astronomer, John Cruickshank, who died in 1875, only reported his data (made when he was 12 years old) some 66 years afterwards—perhaps a record for late submission of results as Dave suggested!

After the final break, in a session chaired by the Director of the Calton Hill Observatory, Jamie Shepherd, Dr. John Mason continued the Leonid theme by reviewing prospects for the shower in the coming decade. His interpretation of previous returns suggested that enhanced activity could occur between 1995 and 2004 or so, with the hoped-for storm possibly taking place in any of the years from 1997 to 2000. He urged all observers to begin monitoring this shower now however, to provide information about pre-enhanced rate levels as well as to spot the first signs of the storm's approach.

Godfrey Baldacchino, the very active and enthusiastic meteor astronomer from Malta who is working in Britain this year, then painted a picture of meteor work in the islands of Malta and Gozo, and related tales of some of the experiments the Maltese observers have carried out into the practical aspects of meteor watching since the late 1970s. He also told us of some customs held near San Lawrenz in Gozo around the Perseid maximum in August, the Perseids sometimes known as the "Tears of St. Lawrence" whose day is August 10 and after whom the village is named.

The day's closing speaker was Philip Bagnall of the Society of Meteoritophiles, who briefly told of this new society, which is for all interested in collecting meteorites.

George Spalding closed the meeting at about 5^h p.m. by thanking all the participants and speakers for their time and contributions, and looked forward to another BAAMS meeting in Edinburgh before the year 2001 (the previous such meeting in Edinburgh was held ten years ago!). The fifty or so attendees all agreed that it had been a highly informative and thoroughly enjoyable day.

Asteroids, Comets, Meteors IV

Flagstaff, Arizona, June 24–28, 1991

Jürgen Rendtel

The previous ACM conferences were held in Uppsala, Sweden, in 1983, 1985, and 1989. This time, about 300 participants, among them amateurs as well, met in Flagstaff, Arizona. The area seems to be attractive to astronomers and we also find a well-conserved impact structure nearby. An excursion to the Canyon Diablo Meteor Crater was organized in the middle of the conference. Despite all the background knowledge and the explanations it remains unbelievable that this hole in the surface was caused within a few seconds by an iron meteorite with a diameter of "only" 30 meters.

The conference consisted of plenary meetings and parallel sessions dealing with different topics each afternoon. It is impossible to review all parts of the program. More than 250 pages of abstracts were published in advance! So I will try to summarize some topics of the meteor branch, although even this will be incomplete and it is only a personal view.

Except for the Geminid meteoroids, the bulk densities of meteoroids were assumed to be definitely below 1 g/cm^3. Calculations including gross fragmentation give strong hints on densities in the range of 3 to 4 g/cm^3 at least for photographic meteors. Although the model cannot simply be used for high velocity entries (as for cometary showers), also the cometary material may be of higher density than 0.3 g/cm^3 (Ceplecha and McCrosky; Babadzhanov).

In the past, there occurred Lyrid peaks of high activity with typical durations of 20 minutes. Lindblad found that all observed peaks occurred at the same solar longitude. Thus there may exist a relatively stable filament and due to the short time the peak may have been missed many times.

At a poster, J. Hartung connected the Corvids (observed once by Hoffmeister) and the lunar impact having caused the Bruno crater (an observation which is not without doubts). Since ejecta from this impact may be observed after their retun to the Earth-Moon-System as low velocity meteoroids, there is a chance of interrelation. More interesting for the observers, he expects a Corvid shower in 2003 or 2006.

Some years ago the Quadrantids obviously had no related parent object. Step by step a parent comet as well as a "family" of showers belonging to a complex was "obtained". Babadzhanov introduced eight meteor showers. Two of them are not detected yet and could prove the connections.

Furthermore, the interrelations between professional astronomers and amateurs were discussed. Prof. Keay (President of the IAU Commission 22 at that time) and Dr. Stohl (new President of this Commission) decided to select six consultants from amateur groups world-wide, three of them from *IMO*. These consultants should pass information of interest into both directions, such as data requested or observational projects. The other groups presenting consultants are the Nippon Meteor Society, the BAA Meteor Section and the Dutch Meteor Society (one each).

One project which will be started immediately from the amateurs is the *International Leonid Watch (ILW)* initiated by Peter Brown. An open discussion yielded several interesting possibilities for future observations. The project will last from 1991 at least until 2003, but probably even longer.

Of course, the many talks with specialists gave an impression about the research which is done in the field of minor bodies in the Solar System. Also the "European" *IMO* members Detlef Koshny and myself met the "North-American" Peter Brown. Meteor observations under the clear sky of Arizona showed that the scales developed independently (meteor magnitudes, angular velocities) agreed very well—an additional proof of the reliability of different data which are checked by statistical means normally. The conference as well as the additional meetings showed that serious amateur data are welcomed by professional astronomers—not only visual but also other kinds of data. There remains some work to be done by *IMO* in the near future.

Book Review

Paul Roggemans

Jürgen Rendtel, "Sternschnuppen", Urania Verlag, Leipzig-Jena-Berlin, 1991, 126 pages, price: 16.80 *DEM, ISBN 3-332-00399-2.*

It is a long time ago since a book on meteors appeared in the German languager. The best known books thus far were "Meteorströme" by Cuno Hoffmeister (1948) and "Physikalische Theorie der Meteore und die Meteoritische Substanz im Sonnensystem" by Boris Lewin (1961), the latter being a translation of a work previously published in Russian. With over 100 million German speaking Europeans, a new standard book dealing with meteors was overdue, after 30 years.

Shooting stars are known among people, but the subject is usually very poorly covered in general astronomy textbooks. People who want to know more about these remarkable meteors will find exactly what they need in this new book. The author combined his practical experience as observer and photographer with his more theoretical background knowledge to introduce meteor astronomy in a fascinating way. The book contains many photographs and very fine illustrations, all produced with great skill.

The book starts with an account of a meteorite dropping in Germany in 1985, and from this spectacular event onwards the meteor phenomenon is explained. A lot of pages are reserved for a detailed description of the major meteor streams, covering their most interesting historical appearances and their visibility in recent times. The characteristics of sporadic meteors are also very well covered: an important aspect that is often missing in other books. A chapter about fireballs and meteorite impacts covers all aspects of these events, very worthwhile for people who once witnessed a fireball. Finally, some hints to go out and observe are provided to those who became strongly motivated after reading the book.

This work is not intended as a handbook with very detailed instructions for any observing technique, but rather gives the major principles. It also contains a glossary of the terms used in meteor astronomy. The literature list contains only German publications, obviously since the book will be distributed among German-reading people.

"Sternschnuppen" is a nicely written book that reads easily. Despite the fact that German is not my native language, I experienced no difficulties in going through this work. It keeps the attention of the reader alive, who becomes more and more interested while progressing in the book, as if it were a thrilling crime story. Although being an exact scientific work, the level is easily accessible to anyone, even without too much expertise in astronomy. It is ideally suited for any amateur or professional astronomer who wants to have some reference work at hand about meteors. The price is very low and the quality of the edition, lay-out and illustrations is outstanding. The work is strongly recommended to anyone who can read German.

The 1990 Observational Report

Paul Roggemans

The third report in the *WGN Observational Report Series* is published, and again contains more pages than the two previous editions. By ordering a copy of this report you help *IMO* in two ways: first, you help to distribute the *IMO* observational results and, second, you enable the future production of such reports.

Since all delay has been worked away now, it is our intention to compile the 1991 Report as soon as in April 1992, trying to get the report over the previous year printed in May, from next year onwards. In order to be able to do so, it is necessary that all observers, groups and cooperating societies send in their visual reports and fireball forms as soon as possible. It would help us a lot if an effort can be made at the side of the observers to deal with their observing report in such a way that we get their reports within two or maximum three months after the observations. Entering such enormous mass of observational reports can be done only when we receive data for input regularly throughout the year. If everything comes together at the last moment, we simply cannot survive the work load! We wait for your 1991 reports ...

A meeting on **Desktop Publishing in Astronomy and Space Sciences** will take place in the Strasbourg Astromical Observatory (France) from October 1 to 3, 1991. For further information, please contact *Christian Steyaert*.

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Other author's addresses

N. White, 5, Fairfield Rd., Isham, Kettering, Northants. NN14 1HF, *England, UK*
D. Artoos, Nattenhofstraat 74, B-2800 Mechelen, *Belgium*
D.W. Olson et al., Dept. Phys., SW Texas State Univ., San Marcos, *TX 78666-4616, USA*
G.M. Kristensen, Vænget 13 st. th., DK-4622 Havdrup, *Denmark*
Sichao Wang, Purple Mountain Observatory, Academia Sinica, Nanjing, 210008, *China*
M. Vints, Acacialaan 35, B-3583 Beringen, *Belgium*
P. Pravec, Astronomical Institute, CS-25 165 Ondřejov, *Czechoslovakia*
A. Grishchenyuk, Astronomical Observatory of the Crimean
Regional Young Technicians Station, P.O. Box 52, Simferopol, *Crimea* 333 000, *USSR*
E. van Ballegoy, Willemsweg 41, NL-6531 DB Nijmegen, *the Netherlands*
G.K. Renner, Rua Ramiro Barcellos 1820A P801, 90210 Rio Branc, Porto Alegre, *RS, Brazil*
J.M. Trigo, Avda Antic Regne de Valencia 35, 9 aptda, E-46005 Valencia, *Spain*