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This beautiful magnitude −5 Perseid in Cygnus was photographed by Drago Sirovica from the Croatian Island of Prvić in the Adriatic Sea on August 13, 1994, at $1^h31^m30^s$ UT. The exposure was made from $1^h30^m$ UT till $1^h32^m$ UT with a Kiev 2/53 camera on an Efke KB 400 film.

In this issue:



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# Useful Information

## The December Issue *(WGN 22:5)*

The *December issue* will be mailed during the last week of November or the first week of December, to avoid the Christmas and New Year jam in the mail. The December issue will also be a thick one. Contributions are due *November 10* at the latest. They should be sent to *Marc Gyssens.*

## WGN Subscription/IMO Membership 1995

The subscription rate for Volume 23 (1995) of the *Bimonthly Journal* is 35 DEM for six issues which are anticipated to contain over 250 pages in total. A combined subscription with the *Report Series* and *FIDAC News* costs 70 DEM. You can also become a Supporting Member by paying at least 15 DEM extra. More information can be found on the first page of this issue.

## Administrative Correspondence

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

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

# From the Editor-in-Chief

*Marc Gyssens*

*In 1994, the summer was again a good one for meteor workers. As you have read in the previous issue, the Perseids again performed excellently, this time primarily for American West Coast observers. The data that are already available are very consistent and show a nice profile of the activity, as the participants of the* 1994 International Meteor Conference *have witnessed. Unfortunately, some data are still lacking in order to be able to present a good 24-hour coverage of the shower in the days around the maximum. Since it is our firm intention to publish a preliminary report on the 1994 Perseids in the December issue, we urge all observers who did not yet send in their observations to do so at once! Most other articles we received pertaining to the 1994 Perseids will also be published in the December issue. The current issue is primarily devoted to the 1993 Geminids although a lot of attention is also given to more recent events as well, such as the spectacular daylight fireball which appeared on May 29 over the Dutch North Sea coast.*

*The other highlight of last summer (technically, it was already fall, but the local temperatures surely permit me to use the former term) was the* 1994 International Meteor Conference (IMC) *in Belogradchik, Bulgaria, which was of high quality and excellently organized. As usual, those that stayed at home were wrong! More on this* IMC *can also be found in this issue. The excellent tradition of the* IMCs *will of course be continued in 1995; the Council decided that the* 1995 IMC *will take place near the historic city of Brandenburg, in the German state of the same name. A pre-announcement of this event can also be found elsewhere in this issue.*

*Finally, October is the month in which we ask you to renew your membership or subscription. Unfortunately, the evolution of both printing and mailing costs, as well as the tendency to produce more thick issues than in the past, forced the Council to increase the fees by 10 DEM. We ask for your understanding for this necessary measure and hope that you will remain faithful to your journal. We, on the other hand, hope to maintain the new membership/subscription fees at the new level for several years to come. Finally, I ask for your cooperation to renew* early *so that we can keep our records straight!*

*Enjoy reading this issue; we on our part have already started preparing the Decenber issue which will again be a thick one!*

# 1995 Membership and Subscription Renewal

*Ina Rendtel and Marc Gyssens*

At the *IMC* in Belogradchik, the *IMO* Council has decided to raise the annual **membership/subscription dues** to **35 DEM** to keep track of rising printing and mailing costs. People outside Europe wishing **airmail delivery** pay **50 DEM**. In addition, the Council has decided to offer a **combined subscription** to the three periodical series of *WGN* (the *Bimonthly Journal*, the *Observational Report Series*, and *FIDAC News*) for just **70 DEM**. People outside Europe wishing **airmail delivery** pay **90 DEM** for this combined subscription. **Supporting Members** pay **15 DEM extra**. Very few Supporting Members in 1994 made use of the possibility offered to them of having their picture and a short description of their activities printed in *WGN*; please make use of this possibility: in this way, your colleagues get to know you!

Preferably, payments should be made in in German marks (DEM) to the **postal (giro) account** of **Ina Rendtel**, Gontardstraße 11, D-O-1570 Potsdam, Germany. The account number is 5472 34-107 and the post office code is 100 100 10 (Postgiroamt 1000 Berlin). **Please note that post office code and postgiroamt must always be mentioned together with the postal account!** Alternatively, you can also pay Ina by **international postal money order**.

If you do not mind violating some postal regulations and if you are prepared to take the risk, you could also consider sending the required amount to Ina **cash**, in bank notes. This is by far the easiest way to pay! To reduce the risk, make sure that the bank notes are not visible through the envelope!

People who can only pay **from a bank account** should make an **international bank draft** payable in USD to **Peter Brown** (address on inside of back cover). In this case the membership/subscription dues (this journal only) are 30 USD (without airmail delivery) or 35 USD (including overseas airmail delivery for destinations outside Europe). The combined subscription then costs 55 USD (without airmail delivery) or 65 USD (including overseas airmail delivery for destinations outside Europe). Supporting Members pay 10 USD extra. Please, **do not send checks to Ina Rendtel!**

People who usually pay through other channels in their local currency should contact the relevant person for the appropriate exchange rates. All addresses can be found on the inside back cover.

In order to save on bank costs, you can combine your renewal with the ordering of other *IMO* publications, but please indicate clearly what exactly it is that you pay for! To conclude, a few more words regarding your payment. First, indicate in the message accompanying your payment exactly what you order. Finally, please **renew early**! By renewing early you help us by allowing us to determine accurately on how many copies we need to print volume 23 of *WGN*! As well, we then do not need to send you back issues afterwards, which is time-consuming business. Thank you for your understanding and your cooperation!

# Letters to WGN

*compiled by Marc Gyssens*

**Clouds and meteor observers**

*Usually, clouds (and the precipitation they produce) are considered the prime enemy of meteor observers. As there is little we can do as this enemy "attacks," it is perhaps not a bad idea to take the same attitude as Richard Taibi during his observations of the Geminids.*

When I stepped out of my home the sky was completely cloud-free. That night was the Geminid maximum. Anticipation of bright meteors in a clear sky filled my mind as I started to drive to my site 50 kilometers away. En route, my attention was distracted to the upper right portion of my windshield. Swapping down from Gemini was a blue −6 fireball. Then I saw thin high altitude clouds. As the fireball passed behind them, the clouds' ice crystals diffused the meteoric streak into a broad bond of blue light. I pressed the accelerator harder, impatient to be observing.

At my site, twenty minutes later, the sky was 80% covered with translucent cirrus. I realized that the sky cover and lowering limiting magnitude were ruinous for possible data if the clouds persisted.

Fifteen minutes of observation confirmed my gloomy prediction. Instead of clear skies approaching, the thin clear bonds at the western horizon were only breaks in pervasive clouds. What to do? Go home? The data would not be useful, so why stay? Reasons to stay were that I was prepared and equipped to stay a few hours. And, I noticed that the meteors put on a good show despite the unwanted clouds.

If the Geminids can persist despite interference maybe I will too, I thought. I also realized that poor conditions had an advantage. I could settle back in my sleeping bag and simply enjoy the sky show.

Enjoy the show I did. Third and fourth magnitude meteors were visible in sky breaks between clouds. Minus three and four fireballs' brilliance defied the clouds and showed through them. In one hour I had seen fourteen meteors. Sometimes there was only two minutes between Geminids.

During longer meteor gaps, I noticed night-time phenomena I usually disregarded while gathering more relevant data on clear meteor nights. Flocks of migrating geese and ducks could be heard about a kilometer away, and overhead too. The night was so still, they seemed nearer. Small field animals rustled through a nearby meadow. For the first time at this site, I noticed distance-dimmed lights on the bridge over the Potomac River between Southern Maryland and Virginia. I recalled having made a two hour drive over that bridge to visit the family estate of George Washington and Robert E. Lee, Commanding General of the Confederal States. Recollections of the visits come back to mind and scenes of the estates reappeared in my mind.

When I realized how many mental and natural events occurred during gazes in the celestial one's, I was satisfied with my decision to stay longer and look at the wispily clouded sky. Pleasant "observing" experiences can also be had with ones ears, memory and knowledge of the surrounding geographic area. On the way home, I decided I had not suffered greatly by being "clouded out!"

*Richard J. Taibi*

# Frequently Asked Questions on Observing Methods

*compiled by Rainer Arlt*

**What is the best way to determine a reliable value for the limiting magnitude?**

It turned out that a very unprejudiced and convenient method to determine the limiting magnitude is to count the number of visible stars in certain areas on the sky. There are 27 such regions all over both the northern and southern hemisphere. The more stars you can see, the fainter the limiting magnitude is. The tables to obtain the limiting magnitude from the numbers of stars are published in the *Handbook of Visual Meteor Observations* and in the *Hints for Visual Observers*.

Some limiting magnitude areas bear systematic problems. If the observer has sensitive eyes but cannot resolve close stars very well, he will probably encounter difficulties with area 14 in Cygnus. It is recommended to these observers not to use this area when the limiting magnitude is better than $6\overset{\mathrm{m}}{.}2$ (i.e., if more than 16 stars would be visible).

Area 1 in Draco has a significant gap in the limiting magnitude levels. It jumps from $5\overset{\mathrm{m}}{.}3$ to $6\overset{\mathrm{m}}{.}0$ between 10 and 11 visible stars. If you see 10 stars, it is not clear whether the limiting magnitude was $5\overset{\mathrm{m}}{.}3$, $5\overset{\mathrm{m}}{.}5$ or even $5\overset{\mathrm{m}}{.}9$. Hence, switch to another area when you see just 10 stars in area 1. The same problem occurs with area 12 in Serpens/Libra. It jumps from $5\overset{\mathrm{m}}{.}8$ to $6\overset{\mathrm{m}}{.}4$ between 13 and 14 stars.

Since there are a lot of smaller gaps in other regions, it is very obvious that a reliable value of the limiting magnitude can only be obtained when you *count the star numbers in more than one area.* Moreover, you sometimes might be unsure whether a star is still inside or just outside the area. This effect adds a statistical uncertainty to the limiting magnitude estimate. The following points should be taken into account when estimating the limiting magnitude:

- Use 2 or 3 areas where you determine the star numbers; the choice of the areas may change during the night.
- Average the limiting magnitudes of these areas to obtain a mean limiting magnitude.
- Determine the star numbers about every half hour to three quarters of an hour.
- Do not use areas being very low above the horizon (less than 40° elevation), neither is it recommended to observe there at all.
- Different observers will have different limiting magnitudes; every observer should determine his own limiting magnitude.
- An accuracy of the limiting magnitude of only 0.5 is not sufficient for a serious analysis of your data!

# The 1994 International Meteor Conference

## Belogradchik, Bulgaria, September 22–25

*Sirko Molau*

In late September, this year's *International Meteor Conference (IMC)* took place in Belogradchik, a small town in Northwest Bulgaria. Almost 50 European meteor observers from Belgium, Bulgaria, Crimea, Germany, the Netherlands, Rumania, Serbia, and Slovakia, met there and discussed problems and results of their work in the wonderful surrounding of the Balkan mountains with its landscape made of eroded rocks, green valleys and steep hills.

Many participants met already before the conference in Sofia and traveled the last part of the journey together by train. So the informal contacts started already before the actual beginning of the Conference. In Belogradchik, we stayed in a tourist hotel on top of a hill with an impressive view on the mountains. The meeting itself took place in a hall halfway down to the town. The official opening took place on Thursday evening. First, Jürgen Rendtel and Eva Bojurova welcomed the participants. Then, two of the participating Bulgarian meteor observer groups introduced themselves. Roman Charkov and Atanas Gavrailov gave a general idea about meteor observations in Bulgaria. Later, Valentin Velkov introduced the organizers of the conference, the Astroclub "Canopus" in Varna, in an informal way.

On the next morning, the lecture sessions started with some talks about visual meteor observations. Just after the preparation of the posters, Daniel Očenáš presented as the first speaker recent Slovak Perseids observations. He was followed by Andrey Grishchenyuk from Crimea, who introduced the work of his group dealing with their visual Perseid observations in the years 1972 to 1993. He investigated the profile of the shower maximum in that period and compared the situation in the early eighties and nineties of this century. The conclusions about the times of the maxima were followed by some discussion on the question whether it is possible to determine variations in meteor activity from observations of only one observing place.

His colleague Anna Levina gave a talk about similar investigations from visual Quadrantid observations. Here, the group used not only Crimean observations but also the visual database of the *IMO* to have a larger number of observations available. The differences between the Perseids and Quadrantids were obvious and certain features of the latter shower were introduced, although the observational coverage of the Quadrantids is naturally not so good as that of the Perseids.

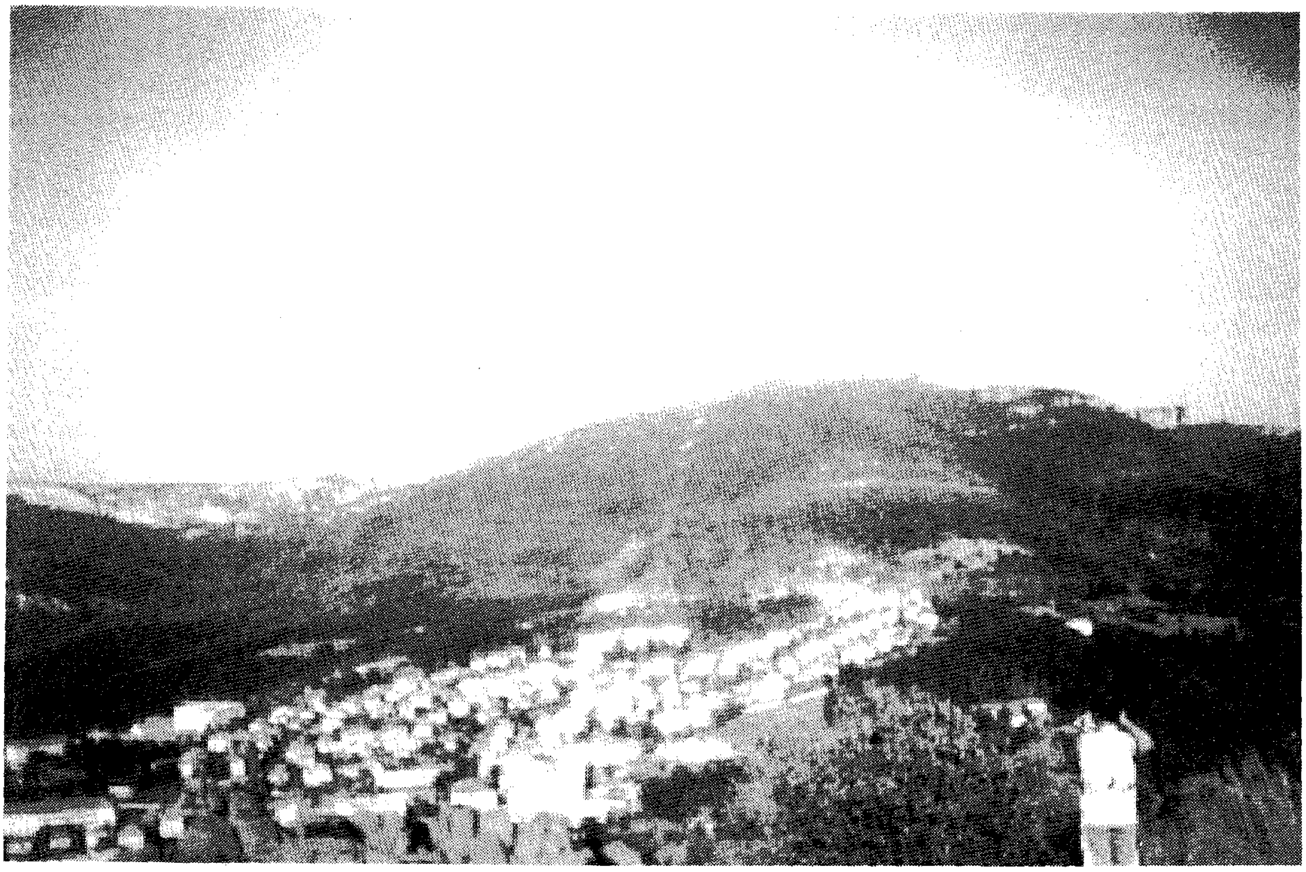

Figure 1 – The town of Belogradchik. Also photographing the scenery is André Knöfel.

The remaining time before lunch was scheduled as a poster session. As the number of lectures was relatively small this year, the poster walls played an important role in the communication and discussions of the meteor observers. Many participants used the time to study the presented material and get into contact with the respective persons. There were two Dutch posters about actual work in meteor photography. The Rumanian group gave impressions from their recent meteor camp and on could read about the actual Bulgarian meteor observations. Different analyses of the Perseids were presented by German and Bulgarian groups, also results of video meteor observations and meteor spectra investigations were presented.

After a delicious lunch and a relaxing break on the balcony of the Tourist Hotel (the temperature was about 30° C), the afternoon session started with a presentation by Jürgen Rendtel about the Perseid observations in 1994. He stated that this August nothing unexpected happened. The American observers and a group from Germany witnessed another strong Perseid display at the expected time, comparable to the one in 1993. Due to the better time of the new maximum they watched not only the peak, but could also recognize the steep decrease of the meteor rates directly after the maximum. This confirmed similar observations obtained under worse conditions in the year before. In another investigation the lecturer showed that, even under very high meteor rates, interval lengths shorter than 10 minutes for visual observations do not lead to new information in the meteor rate profile.

Due to the absence of radio workers, the following video and photographic lectures made up the only non-visual part of this *IMC*. First, Sirko Molau introduced basic algorithms for the analysis of video meteors. In the last year, he implemented an analysis program and started to analyze the Perseid video observations of his group from 1993 and 1994. On the basis of these data, he could present video ZHRs and a radiant plot for the Perseids. Furthermore, he found systematic differences between visual meteor brightness estimates and the video data. Finally, other possible investigations for video workers, like parallax observations, meteor cluster search, and spectra recordings, were suggested.

Afterwards, Marc de Lignie spoke about similar procedures for meteor photographs. He checked the suitability of photo CD for the measurement of meteor photographs and came to the conclusion that both the price and the achieved accuracy and efficiency makes this method a real alternative to the classical way of measurements. He developed a computer program for the analysis of meteors using a photo CD. With that he could show that not only the accuracy does not decrease with this method, but also the efficiency of analysis increases by almost a factor of ten.

After his talk, Marc demonstrated the program and amazed the spectators with how fast and easy photograph analysis can be.

Just before dinner, the Rumanian group presented a video about their first meteor camp during the Perseids in 1994. Due to the strong support by the Rumanian army and other private sponsors they could make it a big success for their meteor group. Such camps will be repeated in the future and the organizers hope to find a lot of new meteor observers.

The day was finished with a short presentation of the results of the Meteoroid Conference in Bratislava in August 1994 by Jürgen Rendtel (*see elsewhere in this issue,* Ed.) and the General Assembly of the *IMO*. After short reports of the present Commission Directors, an increase of the membership and subscription fees to 35 DEM per year was announced, which was largely supported by the participants. This increase is to avoid financial problems with *WGN* in the future and will probably keep the price stable in the next years. Furthermore it was announced that the next *IMC* will take place near Brandenburg in Germany in September 1995.

After the official program for that evening, a small photographic workshop was held in the conference room. The participants fixed main aims of the future photographic work and came to two conclusions. On the one hand, the analysis of single-station photographs should be standardized, and there will be an investigation on what data one can derive from such photographs. On the other hand, simultaneous photographs for parallax measurements should become the ultimate aim for all advanced photographers, as the amount and accuracy of data is much better with this method.

Some other participants spent their evening with hot meteor debates not in the absence of alcoholic drinks, whereas others joined the Bulgarians at the dance floor in the hotel's disco bar, and got to know them from a completely different angle. So, some participants were a bit tired, when André Knöfel opened the next day with a lecture about fireball observations from satellites.

Due to the improving relations between the *FIreball DAta Center (FIDAC)* and the American Department of Defence, it has now become possible to obtain data of fireball observations from military satellites. Of course, there is still a lot of secrecy around that topic, but it is the first time at all that such data are declassified and available to the public. André presented parameters of the most interesting satellites and stated the importance of fast reports from bright fireballs within one week to *FIDAC*. This is essential for the availability of the satellite data and avoids their deletion from the tapes.

In the next lecture, Ralf Koschack dealt with the zenith distance correction factor as proposed by Luis Bellot in *WGN*. He presented his method to check the correction factor and evaluated data from recent observations. Contrary to other papers, he arrived at the result that the scatter of the population index values increases with the introduction of the proposed correction factor. So he concluded that more investigations in this area are needed, before a more complex correction factor should be used in the observation analysis.

Later, Alexander Shopov presented a paper of Eva Bojurova about the population index determination from observations of a small observer group. Using actual observations of the *Astroclub Canopus* from Varna and comparing the data with the global analysis of the *IMO*, he showed that, even for very few observers, $r$-value calculations are quite accurate. All the determined values were within the error bars of the global analysis. Lilia Porozhanova presented a paper of Valentin Velkov, which dealt with an increased activity of the Geminids in 1993. She presented results of group observations and a comparison of perception coefficients for single observers and the whole group, which led to a lively discussion.

After another delicious lunch, the conference participants went on an excursion to explore some of the wonderful sites near Belogradchik. First, we had a two-hour guided tour through the Magura Cave, about 17 km from Belogradchik. Apart from the formations one expects in most Caves, the Magura Cave is very renowned for its prehistoric paintings made with guano. These paintings led to funny translation problems for the guide due to the very explicit way in which male figures are depicted in these 10 000 years old graffiti (see Figure 2). After having left the cave, we went to the Kaleto Fortress constructed around the peculiar rock formations of Belogradchik, where we enjoyed once more the great countryside in the late afternoon sun. Finally, we visited the Belogradchik-based observatory of the Bulgarian Academy of Sciences, which is one of the two professional observatories in Bulgaria. After our last dinner in the Tourist Hotel the evening ended once more in a cheerful atmosphere with wine and beer and some dancing for certain participants.

During the last session on Sunday morning, Jürgen Rendtel presented the results of the photographic workshop, and, once more, the abilities of video observations were discussed in a special workshop.

First, Sirko Molau gave a short introduction into the structure of his video system and presented a short video cut from the latest observation with MOVIE in August 1994. Afterwards Marc de Lignie gave some information about the Dutch observations, which started already in 1987, and the actual investigations in the video area.

Figure 2 – Prehistoric cave painting from the late Bronze Age in the Magura Cave.

Jürgen Rendtel spoke about his experience with an almost professional MCP camera he could use for two weeks. Even though such cameras show the best characteristics for meteor observations, they are unfortunately much to expensive for amateurs. Finally, Felix Bettonvil spoke of his ambitions in the video area and talked about first experiences, although his tests were not that successful as hoped for. The workshop showed again the increasing importance of video work as a powerful observation method in meteor astronomy.

After a final discussion, the conference was officially closed by Jürgen Rendtel and Eva Bojurova. The president of the *IMO* thanked the Bulgarian group for the excellent organization and the big success of the Conference, combined with special thanks to the two most active organizers, Eva Bojurova and Valentin Velkov. Eva replied smilingly that she now knew the most adventurous *IMO* members: those who traveled to Bulgaria.

The 1994 *IMC*in Belogradchik will stay into the memory of the participants as a very interesting and motivating meeting on the one hand, but also as a conference with a relaxed atmosphere and a lot of personal contacts beside the official conference program. Due to the location, many West-European were not present; in return, we had the opportunity to get into contact with many of the very active Bulgarian observers and other groups from East-European countries, who cannot afford to travel to *IMC*s far away in other countries. It is always a good experience to see that, despite language and other barriers, we learn a lot about ongoing amateur meteor work from each other and establish many new contacts and friendships with other observers.

# The 1995 International Meteor Conference

## Brandenburg, Brandenburg, Germany, September 14–17, 1995

*Jürgen Rendtel and Rainer Arlt*

As usually, at the end of the 1994 *International Meteor Conference (IMC)*, the location of the next Conference has been presented. This *IMC* will take place some ten kilometers north of the city of Brandenburg in Germany, in the state bearing the same name, from September 14 to 17, 1995. The site is located at a lake in a more rural area, but can easily be reached by car as well as by public transport. The costs for lodging, meals, and the proceedings are expected to be around 180–190 DEM. More detailed information and a registration form will be included in the December issue of *WGN*.

# Visual Observers' Notes: November–December 1994

*Jeff Wood*

## 1. Introduction

The months of November and December are characterized by the large number of major showers that are active at this time of the year. The Geminids, Puppid/Velids, Ursids, Taurids, and Leonids together with a host of minor streams make for an excellent period of viewing. Even though southern hemisphere observers are favored by summer weather, northern hemisphere observers are to be encouraged to get out and brave the cold winter nights. Table 1 lists some of the more important showers that occur during November and December and Table 2 shows the observing conditions moon-wise.

Table 1 – A list of visual meteor showers to be seen during November and December. Streams marked with an asterisk only produce the indicated ZHR in certain years, and otherwise produce much lower activity.

| Shower | Activity | Max | Radiant | | | Drift | | $V_\infty$ | $r$ | ZHR |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\alpha$ | $\delta$ | Diam. | $\Delta\alpha$ | $\Delta\delta$ | | | |
| Orionids | Oct 02–Nov 07 | Oct 21 | 95° | +16° | 10° | +1°.2 | +0°.1 | 66 | 2.9 | 25 |
| Taurids S | Sep 15–Nov 25 | Nov 03 | 50° | +14° | 10°/5° | Table 3 | | 27 | 2.3 | 10 |
| Taurids N | Sep 13–Nov 25 | Nov 13 | 60° | +23° | 10°/5° | Table 3 | | 29 | 2.3 | 8 |
| Leonids* | Nov 14–Nov 21 | Nov 18 | 152° | +22° | 5° | +0°.7 | −0°.4 | 71 | 2.5 | storm |
| $\alpha$-Monocerotids (Nov) | Nov 15–Nov 25 | Nov 21 | 117° | −06° | 5° | +1°.1 | −0°.1 | 60 | 2.7 | 5 |
| $\chi$-Orionids | Nov 26–Dec 15 | Dec 02 | 82° | +23° | 8° | +1°.2 | 0°.0 | 28 | 3.0 | 3 |
| Phoenicids* (Dec) | Nov 28–Dec 09 | Dec 06 | 18° | −53° | 5° | +0°.8 | +0°.1 | 18 | 2.8 | 100 |
| Puppid/Velids | Oct 15–Jan 22 | several | 120° | −45° | 20°/15° | Table 7 | | 40 | 2.9 | 12 |
| Monocerotids (Dec) | Nov 27–Dec 17 | Dec 10 | 100° | +14° | 5° | +1°.2 | 0°.0 | 42 | 3.0 | 5 |
| $\sigma$-Hydrids | Dec 03–Dec 15 | Dec 11 | 127° | +02° | 5° | +0°.7 | −0°.2 | 58 | 3.0 | 5 |
| Geminids | Dec 07–Dec 17 | Dec 14 | 112° | +33° | 4° | +1°.0 | −0°.1 | 35 | 2.6 | 110 |
| Coma Berenicids | Dec 12–Jan 23 | Dec 19 | 175° | +25° | 5° | +0°.8 | −0°.2 | 65 | 3.0 | 5 |
| Ursids* | Dec 17–Dec 26 | Dec 22 | 217° | +75° | 5° | | | 33 | 3.0 | 50 |

Table 2 – Moonlight and observing conditions in November–December 1992.

| Date | $k$ | Date | $k$ |
|---|---|---|---|
| Friday October 28 | 0.47− | Friday December 2 | 0.02− |
| Friday November 4 | 0.00+ | Friday December 9 | 0.41+ |
| Friday November 11 | 0.58+ | Friday December 16 | 0.96+ |
| Friday November 18 | 1.00+ | Friday December 23 | 0.78− |
| Friday November 25 | 0.63− | Friday December 30 | 0.09− |

| | |
|---|---|
| New Moon: | November 3, December 2, January 1 |
| First Quarter: | November 10, December 9, January 8 |
| Full Moon: | November 18, December 18, January 16 |
| Last Quarter: | October 27, November 26, December 25 |

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.

## 2. 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 early December. They reach a broad maximum in late October and early November. Although the date of maximum for the Southern Taurids is given as November 3 and that of the Northern Taurids as November 13, these were derived from the orbital elements and not from visual observations. At maximum, Taurid activity can be very erratic with rates ranging from 1 or 2 to as high as 10 or 15 meteors per hour.

With the radiant positions reaching culmination just after midnight, Taurid meteors can be observed for most of the night. The Taurid meteor stream is noted for its many bright colored meteors. Although the dominant color is yellow, many orange, green, red and blue fireballs have been recorded. 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*.

Although the Moon affects viewing towards the middle of November, the Taurids are generally free of its influences for most of the period of major activity. Observers are encouraged to carry out an extensive Taurid watch this year. They should center their field of view some 20°–30° east or west of the radiant positions at a declination of +10° to +20°. All possible Taurid meteors should be plotted.

### 1. Leonids and Geminids

The *Leonids* are a meteor shower that has produced meteor storms in the past, the last occasion of which was in 1966. They are a young stream, being produced by the debris of comet P/Tempel-Tuttle which means that, like the parent comet, they have a 33-year periodicity in their maximum activity. As we are now within 5 years of the next return of the parent comet and hence the next predicted storm, Leonid rates should be on the increase. In 1994, the Leonids will be subject to interference from the Full Moon. However, in spite of this, they still need to be monitored to check and see if high rates do occur. The Leonids should be observed during the last few hours before dawn when the radiant is high above the horizon.

The *Geminids* are one of the major calendar events of the meteor year. The Geminids are visible from both hemispheres and provide excellent rates of around 100 meteors per hour each year. The Geminids are active from December 7 to 17 and reach maximum on December 14. They are noted for their many bright yellow-orange meteors. With the Full Moon occurring on December 18, conditions are less than ideal for viewing. However, the shower should still produce good rates and observers are encouraged to get out and monitor it. Due to high rates, observers should use counts most of the time. Plotting of Geminids should be carried out only if the ZHR is less than 10.

### 2. Minor northern-hemisphere showers

The $\chi$-*Orionid* shower is active from November 26 to December 15. A maximum ZHR of 3 is reached in early December. The $\chi$-Orionids are characteristically very slow brightly colored meteors. The *IMO* requires urgent observations of this shower in 1994. Observers should watch with a center of field of view at about $\alpha = 90°$ and $\delta = +20°$. All possible $\chi$-Orionids should be plotted.

The *December Monocerotids* are active from November 27 to December 17 with a maximum ZHR of 5 on December 10. The *IMO* requests that observers give this shower attention. The shower should be observed in conjunction with the Geminids. Care should be taken to distinguish between meteors from both showers. To aid this, the observer's center of field of view should be located at $\alpha = 105°$–$120°$ and $\delta = 00°$–$+20°$. All possible December Monocerotids as well as meteors possibly belonging to the Geminids or Monocerotids (i.e., those difficult to distinguish) should be plotted. Meteors belonging to the Geminids or sporadics should be counted only.

On the nights of December 12-13 and 13-14, it is senseless to analyze the Monocerotids since the activity of the Geminids is vastly superior and the ZHR of the December Monocerotids becomes polluted by the high Geminid activity. Therefore, observers are asked to concentrate on the Geminids on these dates.

The $\sigma$-*Hydrids* radiate out from the head of Hydra during the period December 3–15. Maximum ZHR is 5 and this occurs on December 11. This shower can be monitored simultaneously with the Monocerotids, $\chi$-Orionids and Geminids if a center of field of view of around $\alpha = 105°$ and $\delta = +15°$ is used. All possible $\sigma$-Hydrids seen should be plotted. The *Coma Berenicids* are active from December 12 through to January 23. The maximum of 5 meteors per hour occurs on December 19. They are best seen during the last few hours before sunrise from the northern hemisphere. Northern observers should endeavor to monitor the Coma Berenicids after the period of maximum activity and the Full Moon period of mid-December. Observers should center their field of view within 40° of the radiant position and plot all Coma Berenicid meteors seen.

### 3. Minor southern-hemisphere showers

The *Phoenicids* are active from November 28 through to December 9, with a maximum occurring on December 6. The Phoenicids produce variable activity which ranges generally from 2 to 10 meteors per hour. On a couple of occasions, notably 1956 and 1974, the rates reached 100 and 25 per hour respectively. The Phoenicids are not affected by the Moon in 1994. Southern hemisphere observers should endeavor to get as many observations of this shower as possible. They should center their field of view within 40° of the radiant position and plot all possible Phoenicids seen.

From late October to late January there are a series of radiants active in the constellations Carina, Puppis and Vela. These are known as the "Puppid/Velids." Since there are several sub-streams in the Complex, the Puppid/Velids exhibit several maxima. The strongest of these occur during the month of December and in early January. Rates at this time can reach 12 to 15 meteors per hour. On some occasions, notably during the period December 3 to 12, rates of 20 to 25 meteors per hour have been recorded!

As with all long-duration showers, the Moon is invariably going to affect some of the activity period. With this in mind, the *IMO* requests that southern hemisphere observers concentrate on this shower over the following dates: October 28 to November 13 and November 28 to December 13.

Observers should plot all possible Puppid/Velids seen unless the rate exceeds 10 per hour when classified counts should be made. From December 5 to 13, observers should look close to the radiant area and observe the Puppid/Velids only when the Geminid radiant is below 20° in altitude. Once the Geminid radiant reaches this altitude, they should then concentrate on this shower.

# Bulletin 4 of the International Leonid Watch

*Peter Brown*

Over the last 4 years, the *IMO* has encouraged observers to make an effort to observe the Leonid shower through a special *International Leonid Watch (ILW)*. To date, there have been 3 *ILW* special periods of investigation; namely November 5–25, 1991–1993. The purpose of these observational periods is to provide data on the present activity of the Leonid stream which will then permit better comparison with the (expected) stronger Leonid returns near the end of the decade. Additional information on the *ILW* program can be found in [1–3]. In the next issue, we focus on results regarding the past three periods. Here, we concentrate on the fourth *ILW* period: November 5–25, 1994.

Though the Full Moon will badly interfere with observations of the Leonids this year, observers are strongly encouraged to check activity during this interval, particularly near the maximum. Even with the presence of the moon, a Leonid outburst should be obvious, if it occurs. Based on orbital integration of the motion of the parent comet, Yeomans [4], suggests that the nodal longitude during the 1998 apparition will be near $\lambda_{\odot} = 235^{\circ}\!.28$. If new material is present, one might expect any enhanced activity to occur near the cometary node which corresponds to November 17.8, 1994. Conditions in the week leading up to the peak will be acceptably dark for morning observing; plotting as well as magnitude and rate counts would be valuable. We are currently less than 3.5 years before P/Tempel-Tuttle reaches perihelion and the odds of encountering fresh material which might lead to heightened activity are quickly increasing.

**References**

[1] Brown P., "Proposal for the International Leonid Watch (ILW)", *WGN* 18:5, October 1990, pp. 178–180.

[2] Brown P., "Bulletin 1 of International Leonid Watch", *WGN* 19:5, October 1991, pp. 193–198.

[3] Brown P., "Bulletin 2 of the International Leonid Watch", *WGN* 20:5, October 1992, pp. 207–208.

[4] Yeomans D., *personal communications*, December 1991.

# Call for Meteor Observations around September 10, 1994

*Jürgen Rendtel and Gary Kronk*

In 1993, there were some notes about a suspected meteor activity from a region in Aries/Triangulum during the night of September 11-12. Again, there are some hints about such an activity in 1994, but it was not confirmed by all observers. The radiant should be close to $\alpha = 27°–29°$ and $\delta = +27°–+29°$. We ask all observers to check their plots made around this date for meteors possibly related to this radiant. Most reported meteor trails are rather short, and the associated meteors seem to be quite slow. In order to clarify the observations, we would like to see more reports from the nights between September 7 and 13, giving information about possibly related meteors, the observational period, conditions, and the center of the field of view. Reports should be sent to one of the authors.

# Photographic Observers' Notes: November–December 1994

*Jürgen Rendtel*

During the recent *International Meteor Conference (IMC)* in Belogradchik, there was a photographic workshop to discuss aims and possibilities of this field of meteor work (for details about this see the Proceedings of this conference). As already pointed out in the Photographic Observers' Notes [1], the most valuable contributions can be expected from double-station work. However, we see that many photographs obtained are single-station images. Therefore we will continue to propose projects for this kind of photography. In future articles in *WGN*, you will also learn more about measurements and we certainly will have another photographic workshop during the *IMC* in 1995.

Beyond any doubt, most bright fall meteors are related to the Taurid Complex. There are two branches, the Northern and Southern Taurids. Their maximum activity occurs around November 13 and November 3, respectively. In terms of ZHR, their maxima are not distinct. In a number of years, a remarkable excess of fireballs occurred around November 1.

Taurids are part of the ecliptical meteoroid complex, and their atmospheric entry velocities (29 km/s and 27 km/s, respectively) imply meteors of relatively low angular velocities. Furthermore, the radiants are above the horizon in most parts of the night, even in medium southern latitudes. Thus the prospects for photography are quite favorable.

Single station photographs may help to associate meteors with the southern or northern branches of the Taurids if the fields are appropriately chosen, i.e., being east or west of the radiants. The most suitable field centers for standard lenses are at $\alpha \leq 30°$, $\delta \approx +15°$ (mainly before local midnight) and $\alpha \geq 60°$, $\delta \approx +15°$ (after local midnight). The use of a rotating shutter with known interruption frequency is recommended.

Another promising photographic shower is the Northern $\chi$-Orionids at the beginning of December. It also contains some remarkable fireballs [2]. Although it obviously continues the ecliptical meteor activity, the characteristics of the fireballs of the Taurids and the Northern $\chi$ Orionids are quite different.

The recommended field centers are again west or east of the radiant: cameras with standard lenses should be pointed to approximately $\alpha = 50°$, $\delta = +20°$ or $\alpha = 110°$, $\delta = +20°$.

Normally the November–December Notes should concentrate on the Geminids, but the almost Full Moon leaves only very little room for systematic Geminid photography. You may try some exposures starting already before moonset. The exposure time should be rather short, depending on the amount of stray light. Remember, that the time of the meteor's appearance is very important, and we also need to know the start and end of the exposure with an accuracy of at least 5 seconds. Other, more general, notes about the photographs can be found in [1].

### References

[1] J. Rendtel, "Photographic Observers' Notes: May–June 1994", *WGN* 22:2, April 1994, p. 34.

[2] G.W. Wetherill, D.O. ReVelle, "Which Fireballs are Meteorites? A Study of the Prairie Network Photographic Meteor Data", *Icarus* 48, 1981, pp. 308–328.

# Telescopic Observers' Notes: November–December 1994

*Malcolm J. Currie*

At last the skies cooperated during an observing campaign and there is a new substantial dataset to study. During a series of partially clear nights from August 28 to September 17, I have been able to follow the $\alpha$- and $\delta$-Aurigids, $\beta$-Cassiopeids, and other showers, and accumulated 541 meteors in 31.86 hours on 13 nights. A preliminary graphical analysis reveals a strange series of radiant positions for the $\delta$-Aurigids as if different subcenters are transient within the shower as a whole. Even with a decent-sized data set such as this, small-number statistics and plotting errors could explain this apparent behavior. Thus I should appreciate any observations for this period as soon as possible so that I can include your data in a RADIANT analysis. The plots also reveal some possible radiants, the most likely being a Lacertid shower that lasted until about September 6. About the same time were the strongest southern Piscid telescopic rates I have noticed, but faded during the campaign. This suggests that the telescopic maximum occurs over a week before the visual peak. Finally, the observations show evidence to support Gary Kronk's Triangulid shower. More on this matter will be published in the December issue.

Vanja Rodiger and Chris Hall have contributed observations around the Perseid peak. Vanja plotted 20 meteors on nights during 3.44 hours, and Chris noted 31 meteors in 3.37 hours on three cloud-interrupted nights.

### Forthcoming Events

In contrast with 1993, moonlight will badly thwart attempts to cover the major showers, though some observations are possible and worthwhile. Indeed there is still plenty to see.

The long duration of the *Taurids* makes some part of their display visible every year. This year is more favorable than most as the new moon occurs in the middle of the broad maximum. Despite the lack of small particles in this old stream, depleted by radiative forces such as the Poynting-Robertson effect, telescopic observations can still contribute to Luis Bellot Rubio's project to investigate the Taurid radiants. [1] The familiar long paths and slow angular speed of the Taurids compensate by increasing the probability of detection. Some earlier results suggest different elongations along the ecliptic for the north and south Taurid components. In addition to the primary showers there are other weaker contributors to the Taurid Complex all of which lie on a diffuse cloud of particles. The proximity of these other showers, especially those with large radiants like the Arietids, make their resolution difficult. Although telescopic plotting could resolve average-sized radiants at such separations, poor weather, the paucity of meteors and diffuseness of the radiants means that observations must be compiled over many years. So far that has not happened.

During early November, use charts 55, 74, 76, 139/140, and 141. Try to use as many of the charts on a given night as possible, but if you are limited by time, concentrate on the last three. Please only use chart 140 after November 4, but 139 before then. The reason for this is to maintain a reasonable distance from the radiants. The multiplicity of fields allows for the substantial radiant motion; to minimize the effects of occlusions of the numerous showers, whose positions we aim to find; and it makes the identification of the real radiants easier. In late November and early December use 76, 78, 141, and 143 primarily for the *Northern and Southern $\chi$-Orionids*—other members of the P/Encke family—as well any moribund Taurid activity. Given a choice, use a smaller telescope aperture for the Taurid Complex. Careful speed estimates as well as plotting are needed to resolve the closely packed radiants. I should like to compare the two components, and track the radiants' motions. Concentrate on these fields until December 7, thenceforth you can capture $\chi$-Orionids with the centers for the Geminids (see below).

Adding to complexity is a *$\zeta$-Taurid* telescopic radiant in mid-November, and detected by *BAA* observers during the 1980s. Judging by their speed, these meteors are not part of the Taurid Complex. I should like to know more about this shower, this year including to determine when it begins. It should be possible to monitor this shower simultaneously with the Taurids using the charts listed above.

On the face of it, prospects for the *Leonids* look hopeless as the Moon is Full about a day after the maximum. However, 1961—some five years before the Leonid storm—showed the first signs of life with a peak around 80 meteors per hour. It is 33 years on and perhaps we shall be treated again to a strong display this apparition. Regardless of this, we should take advantage of any pre-dawn clear skies every year as part of the *International Leonid Watch*. Besides telling us more about how material is dispersing in the stream, it may give clues to when the potential storm will occur. As skies are usually cloudy in the north, where the shower is best placed, if it is clear at your site please set your alarm clock early and make a few hours' observation—your data might be the only ones collected at that epoch. Observations made outside the normal activity dates would also be of interest. Since our main goal is to estimate particle fluxes rather than determine radiant parameters, instruments with a wide-field (more than 60° apparent) will collect more meteors, and so are preferred. Suggested charts are 81, 123, and 146. Only use 146 if the elevation of the field exceeds 30°.

The slowest telescopic meteors I have ever seen come from a shower at $\alpha = 85°$ and $\delta = +43°$ around December 6. These may be part of the *$\zeta$-Aurigid* Complex of December and January. If it is, it occurs somewhat earlier than suggested by other observations. No clear picture of this shower has emerged since it was first seen in 1988 where it had a sharp peak, perhaps because it belongs to a large and weak complex. We should try to determine its activity period, and accurate radiant position(s). The charts for the Taurid Complex will be suitable for this shower.

The *Geminid* shower is the best of the year for the telescopic observer. This year, a waxing moon will gradually eat into the darkness as the shower develops, so by the night of maximum observations can only take place after about $3^h$ local time. At many northern locations this still leaves time for nearly three hours' watching. The radiant has multiple concentrations that have been observed well at maximum (in 1990 and 1991), but poorly before December 11. In addition to seeing if the same sub-radiants at maximum are reproducible, we need to bolster the pre-maximum numbers seen in earlier years to investigate the radiant's properties throughout the shower. The long nights in the northern hemisphere make it possible to collect large samples and hence let us estimate fluxes, the time of maximum, and a reliable population index.

Concurrent with the Geminids are two minor showers rich in faint meteors: the *Monocerotids* and the *$\sigma$-Hydrids*. At this time, visual rates are so high that plotting is not possible, as is usually demanded by minor showers, and contamination by an only small fraction of Geminids greatly enhances the apparent rates of the minor shower. So to follow these showers around the Geminid maximum we lean heavily upon video and telescopic methods. The $\sigma$-Hydrids are fast meteors and so we should prefer fields of view that are about $10$–$15^g$ away. However, to cover all the showers adequately, close proximity is not possible for all but a couple of fields. The visual maximum of these showers occurs during the weekend of December 10 and 11. Please try to use as many of the following charts as possible allocating about thirty minutes for each: 56, 77, 81, 99, 123, 143, and 144. Reserves are 55, 98, 103, and 145. This selection should help reduce artifacts and resolve any radiant structure in the Geminids, and allow coverage of the minor showers.

In case the southern-hemisphere observer feels left out there is the fascinating *Puppid-Velid* complex whose structure can be mapped with careful plotting. Many of its components are rich in faint meteors, suggesting that they are worthwhile telescopic targets, though I have no telescopic data to support this view. Visual rates are variable, but no one knows whether or not this is reflected in telescopic activity too. The *Phoenicids* are observable during the evening and are well placed this year. Normal visual rates are those of a good minor shower. Phoenicids will be quite obvious due to their very slow speed.

# Theoretical Radiants of Minor Planets and Comets

*Dirk Artoos*

Below is a list of theoretical radiants of minor planets and comets, some of which may cause meteor activity during November and December.

Table 1 – Theoretical Radiants of Asteroids and Comets in November–December 1994.

| Name | $\lambda_\odot$ | Date | $\alpha$ | $\delta$ | $V_\infty$ | Distance |
|---|---|---|---|---|---|---|
| 1991 GO | 211°09 | Oct 24 | 32° | − 3°7 | 24 km/s | 0.0205 AU |
| P/1457 II | 212°56 | Oct 26 | 5°5 | +24°9 | 26.8 km/s | 0.1703 AU |
| 1987 WC (5569) | 221°56 | Nov 04 | 163°2 | −69°4 | 14.6 km/s | 0.1088 AU |
| 1993 PC | 222°62 | Nov 05 | 44°6 | +25°2 | 18.5 km/s | 0.0658 AU |
| 1993 VA | 223°57 | Nov 06 | 36°7 | − 8°5 | 15.7 km/s | 0.1263 AU |
| P/1987 XIII | 223°9 | Nov 06 | 52°4 | +28°6 | 32 km/s | 0.1941 AU |
| Apollo (1862) | 229°8 | Nov 12 | 224° | −29° | 20 km/s | 0.0273 AU |
| 1989 FB (5803) | 230°95 | Nov 13 | 252°1 | −72°6 | 15.7 km/s | 0.1816 AU |
| 1994 CN2 | 231°44 | Nov 13 | 240°7 | −25° | 17 km/s | 0.0231 AU |
| P/1991 t | 234°4 | Nov 16 | 297°7 | +12° | 16 km/s | 0.0423 AU |
| P/1985 V | 235° | Nov 17 | 297°5 | +12° | 16 km/s | 0.0437 AU |
| 1993 WD =1991 VJ14 | 237°63 | Nov 20 | 117°9 | −29°8 | 32 km/s | 0.1341 AU |
| 1994 GK | 239°12 | Nov 21 | 48°9 | + 5°6 | 19.3 km/s | 0.0700 AU |
| P/1944 I | 239°73 | Nov 22 | 132°5 | − 8°4 | 68 km/s | 0.0447 AU |
| Sisyphus (1866) | 240°67 | Nov 23 | 174°5 | −64° | 27 km/s | 0.0918 AU |
| P/1954 II | 241°68 | Nov 24 | 85°7 | +19°9 | 46.4 km/s | 0.1907 AU |
| Cerberus (1865) | 242°01 | Nov 24 | 78° | +49°4 | 20 km/s | 0.1523 AU |
| P/1771 | 244°01 | Nov 26 | 41°6 | − 9° | 21.7 km/s | 0.1173 AU |
| P/1852 III | 244°97 | Nov 27 | 25°7 | +41°6 | 20 km/s | 0.0138 AU |
| P/1781 II | 246°00 | Nov 28 | 140° | + 0°2 | 67.2 km/s | 0.1861 AU |
| 1988 XB (5746) | 247°6 | Nov 30 | 253°1 | −30° | 17.3 km/s | 0.0053 AU |
| P/1969 VII | 253°32 | Dec 05 | 56°8 | + 4°6 | 24.7 km/s | 0.1373 AU |
| P/1806 I | 253°86 | Dec 06 | 25° | +47°8 | 19 km/s | 0.0013 AU |
| P/1770 I | 254°4 | Dec 06 | 261°8 | −20°8 | 23.6 km/s | 0.0235 AU |
| P/1812 | 255°03 | Dec 07 | 202°2 | +71° | 49 km/s | 0.1983 AU |
| P/1798 II | 256°3 | Dec 08 | 164° | +33°2 | 70 km/s | 0.1297 AU |
| P/1962 IV | 259°8 | Dec 11 | 111°3 | −24°3 | 46.7 km/s | 0.0010 AU |
| Phaethon (3200) | 262° | Dec 14 | 113°5 | +32° | 35 km/s | 0.0254 AU |
| P/1931 IV | 262°75 | Dec 14 | 131°2 | +20° | 59 km/s | 0.0631 AU |
| P/1917 I | 262°87 | Dec 14 | 103° | + 8°8 | 43 km/s | 0.0665 AU |
| P/1618 III | 263°71 | Dec 15 | 182° | − 9° | 25 km/s | 0.0847 AU |
| P/1895 III | 263°73 | Dec 15 | 185° | −58° | 46 km/s | 0.1169 AU |
| P/1846 VII | 267°54 | Dec 20 | 204°8 | + 4°8 | 66.5 km/s | 0.0406 AU |
| Oljato (2201) | 268°9 | Dec 21 | 85°7 | +19°5 | 23 km/s | 0.0092 AU |
| P/1935 I | 271°6 | Dec 23 | 115°5 | −53° | 45 km/s | 0.1653 AU |
| P/1818 III | 272°03 | Dec 24 | 169° | −38° | 65 km/s | 0.1347 AU |
| P/1652 | 272°43 | Dec 24 | 191°5 | −60° | 47 km/s | 0.1095 AU |
| P/Machholz-2 | | | | | | |
| part b | 272°58 | Dec 24 | 288°6 | + 2°5 | 23 km/s | 0.1086 AU |
| part a | 272°63 | Dec 24 | 288°6 | + 2°6 | 23 km/s | 0.1088 AU |
| Khufu (3362) | 272°7 | Dec 24 | 104° | + 5° | 19 km/s | 0.1515 AU |
| Tantalus (2102) | 274°6 | Dec 26 | 135° | −45° | 35 km/s | 0.0281 AU |
| P/1680 | 276°44 | Dec 28 | 133°8 | +21° | 52 km/s | 0.0123 AU |
| P/1883 I | 279°11 | Dec 30 | 242°5 | +26°4 | 47 km/s | 0.0976 AU |
| 1969 IX | 281°8 | Jan 02 | 232° | −56°8 | 49 km/s | 0.0120 AU |
| 1819 IV | 283°8 | Jan 04 | 336°7 | −38° | 18 km/s | 0.0754 AU |
| 1888 III | 284°32 | Jan 04 | 134° | −36°8 | 44 km/s | 0.1649 AU |
| 1870 III | 285° | Jan 05 | 159° | − 5°7 | 65 km/s | 0.1024 AU |
| P/1991 h1 | 288°8 | Jan 09 | 159° | +31° | 53.7 km/s | 0.0019 AU |
| 1966 IV | 289°3 | Jan 09 | 112° | −37°7 | 35 km/s | 0.0626 AU |
| 770 | 289°32 | Jan 09 | 157° | −20° | 59 km/s | 0.0828 AU |
| P/1852 III | 290°5 | Jan 11 | 0°5 | +42°6 | 18 km/s | 0.1964 AU |
| P/1806 I | 291°37 | Jan 11 | 357°6 | +47° | 18 km/s | 0.1666 AU |
| 1994 LX | 292°57 | Jan 12 | 80°5 | −70°8 | 25.5 km/s | 0.1710 AU |

# Progress in Meteor Science

*Articles in this section have been formally refereed by at least one professional and one experienced, knowledgeable amateur meteor worker, and deal with global analyses of meteor data, methods for meteor observing and data reduction, observations with professional equipment, or theoretical studies.*

# A Global Analysis of the 1993 Geminids

*Rainer Arlt and Jürgen Rendtel*

The analysis of global data of the 1993 Geminids shows a maximum ZHR of $130 \pm 8$ at $\lambda_\odot = 262\overset{\circ}{.}1 \pm 0\overset{\circ}{.}1$. This is a somewhat higher peak ZHR than in 1991 and 1992. Similar to previous returns, the rate profile is slightly skew, with a more steep decrease after the peak. Problems occur with the correction of perception because of the distribution of observational data. The lowest value of population index of $r = 2.27 \pm 0.03$ coincides with the rate maximum.

## 1. Introduction

After the splendid coverage of the Perseid event in August 1993 by observations from around the world other showers have been somewhat disregarded for the excitement of the Perseids. Although the weather in central Europe was not favorable for Geminid watches, the well-established net of observers in other parts of Europe, in America, Asia, and Australia delivered a good deal of observations which enabled us to present this analysis. The authors would like to thank the following 133 observers who contributed their observations to this study for their efforts:

Sinsuke Abe (ABESI, 1$^h$58), Mateja Albreht (ALBMA, 1$^h$05), Luis R. Bellot (BELLU, 4$^h$73), Neil Bone (BONNE, 2$^h$00), Jose Antonio Caceres (CACJO, 4$^h$43), Ricard Casas Rodríguez (CASRI, 2$^h$18), Roman Chakarov (CHARO, 8$^h$15), Bih-Lin Chong (CHOBI, 12$^h$91), Ren-Yuh Chong (CHORE, 14$^h$59), Maurice Clark (CLAMA, 14$^h$32), Peter Craven (CRAPE, 1$^h$00), Jozef Csipes (CSIJO, 0$^h$88), Uroš Cvelbar (CVEUR, 0$^h$73), Peter Dalakov (DALPE, 4$^h$99), Mark Davis (DAVMA, 7$^h$50), Vincent Devore (DEVVI, 3$^h$67), Galina Dimitrova (DIMGA, 2$^h$80), Robert Doe (DOERO, 0$^h$92), Peter Dolinsky (DOLPE, 2$^h$68), Phyllis Eide (EIDPH, 10$^h$02), Tositake Fukuhara (FUKTO, 2$^h$67), Kai Gaarder (GAAKA, 15$^h$79), Adrian Galea (GALAD, 3$^h$54), Atanas Gavrailov (GAVAT, 5$^h$67), Jaroslav Gerboš (GERJA, 4$^h$81), Ivanka Getsova (GETIV, 5$^h$35), Vincent Giovannone (GIOVI, 1$^h$00), George W. Gliba (GLIGE, 3$^h$00), Shelagh Godwin (GODSH, 6$^h$99), José Gomez Castaño (GOMJO, 2$^h$00), Victor Gonzalez (GONVI, 1$^h$49), Ian Gray (GRAIA, 4$^h$01), Keith Green (GREKE, 1$^h$84), Valentin Grigore (GRIVA, 12$^h$63), Debbie Harrelson (HARDE, 1$^h$84), Joy Harvey (HARJO, 9$^h$42), Takema Hashimoto (HASTA, 7$^h$42), Yukiti Hattori (HATYU, 3$^h$75), Paul Haworth (HAWPA, 1$^h$80), Robert Hays (HAYRO, 1$^h$00), Lars Trygve Heen (HEELA, 15$^h$69), Trond Erik Hillestad (HILTR, 13$^h$08), David Holman (HOLDA, 13$^h$25), Terry Holmes (HOLTY, 1$^h$33), Oomi Iiyama (IIYOO, 2$^h$28), Kiyoshi Izumi (IZUKI, 2$^h$92), Anne Jokinen (JOKAN, 1$^h$50), Toshio Kamimura (KAMTO, 1$^h$44), Petteri Kankaro (KANPE, 1$^h$17), Fumihiko Kanno (KANFU, 2$^h$82), Junichi Kasei (KASJU, 5$^h$24), Kazuko Kawamura (KAWKA, 1$^h$00), Timo Kinnunen (KINTI, 2$^h$63), André Knöfel (KNOAN, 1$^h$57), Matjaž Kosec (KOSMT, 0$^h$67), Tarou Kuribayasi (KURTR, 4$^h$72), Taiiti Kurosawa (KURTA, 0$^h$83), Andrej Lampe (LAMAN, 2$^h$00), Anna S. Levina (LEVAN, 0$^h$83), Robert Lunsford (LUNRO, 16$^h$97), Daniel Marín (MADAN, 2$^h$78), Katuhiko Mameta (MAMKA, 6$^h$00), Alicia Mania (MANAL, 12$^h$74), Krasimir Manov (MANKR, 5$^h$72), Takuya Maruyama (MARTA, 0$^h$92), Khalid Marwat (MARKH, 9$^h$12), Yukihisa Matumoto (MATYU, 6$^h$67), Alastair McBeath (MCBAL, 16$^h$50), Tom McEwan (MCETO, 4$^h$01), Earl Mead (MEAEA, 1$^h$00), Frank Melillo (MELFR, 2$^h$50), Javier Méndez Álvarez (MENJA, 7$^h$00), Vasile Micu (MICVA, 3$^h$88), Koen Miskotte (MISKO, 2$^h$52), Robert J. Modie (MODRO, 1$^h$00), Sirko Molau (MOLSI, 4$^h$66), Alfonso Murias Núñez (MURAL, 2$^h$38), Michael Morrow (MORMI, 10$^h$13), Motoyuki Nakaura (NAKMO, 2$^h$67), Sin Nakayama (NAKSI, 3$^h$00), Atanas Nikolov (NIKAT, 8$^h$00), Masayuki Oka (OKAMA, 10$^h$35), Hiroyuki Okayasu (OKAHI, 1$^h$50), T. Oldroyd (OLDT , 1$^h$00), Diliana Porozhanova (PORDI, 8$^h$44), Lilia Porozhanova (PORLI, 6$^h$05), David Preston (PREDA, 1$^h$84), Jože Prudič (PRUJO, 1$^h$12), Leo Rajala (RAJLE, 1$^h$13), Pia Rämä (RAMPI, 1$^h$82), Martin Rapavy (RAPMA, 4$^h$96), Pavol Rapavy (RAPPA, 4$^h$91), Jürgen Rendtel (RENJU, 4$^h$29), Francisco Reyes Andrés (REYFR, 6$^h$25), Ian Rigney (RIGIA, 6$^h$18), Neil Roach (ROANE, 9$^h$30), Alejandro Rodriguez (RODAL, 2$^h$78), Paul Roggemans (ROGPA, 7$^h$85), Tuomo Roine (ROITU, 1$^h$00), Antonio Román Reche (ROMAN, 1$^h$32), Angeles Rute Perez (RUTAN, 1$^h$30), Hiromi Sato (SATHI,

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$11^h.11$), Koetu Sato (SATKO, $15^h.91$), Tatuo Sato (SATTA, $6^h.64$), Brian Shulist (SHUBR, $7^h.50$), Yasuo Shiba (SIBYA, $5^h.09$), Hiroyuki Sioi (SIOHI, $2^h.50$), James N. Smith (SMIJN, $1^h.33$), George Spalding (SPAGE, $4^h.74$), Plamen Stoichev (STOPL, $8^h.83$), Dmitryi Suchov (SUCDM, $2^h.75$), David Swann (SWADA, $1^h.92$), Christoffer Swanström (SWACH, $1^h.25$), Richard Taibi (TAIRI, $4^h.02$), Syoiti Tanaka (TANSY, $2^h.66$), Marko Toivonen (TOIMA, $2^h.03$), Hiroyuki Tomioka (TOMHI, $3^h.83$), Simon Tonkin (TONSI, $4^h.96$), Tuomas Törrönen (TORTU, $1^h.50$), Dávid Tóth (TOTDA, $3^h.06$), Josep M. Trigo Rodriguez (TRIJO, $5^h.27$), Yoshiaki Uyama (UYAYO, $3^h.67$), Valentin Velkov (VELVA, $8^h.40$), Roger Venable (VENRO, $4^h.94$), Robert Vyboch (VYBRO, $1^h.43$), Chris Watson (WATCH, $1^h.00$), Roy Watson (WATRO, $1^h.50$), Vic Winter (WINVI, $7^h.10$), Jeff Wood (WOOJE, $17^h.88$), Yasuo Yabu (YABYA, $17^h.34$), Satiko Yamaguti (YAMSA, $1^h.50$), Chen Yu (YU CH, $0^h.83$), and George Zay (ZAYGE, $19^h.03$).

Due to interference from the Moon, the 1992 Geminids could not be monitored appropriately. Not even 1400 shower meteors were recorded in 1992; too small a number to permit a global analysis. (A raw estimate of the activity showed a maximum of $ZHR_{max} = 100 \pm 20$ at $\lambda_\odot = 261.^\circ9 \pm 0.^\circ2$ for the 1992 Geminids.) The last comprehensive study of the Geminids presented in this Journal dealt with the 1991 Geminid return. The analysis routines of the *Visual Meteor Database (VMDB)* were used for investigating both the 1991 and 1992 returns. The present paper regarding the 1993 return is based on 20 700 shower meteors seen in 668 observation hours. The analysis routines of the *VMDB* were also applied to obtain the results presented in this paper.

## 2. The population index

The individual population indices $r$ were computed according to [1]. To be used in the analysis, the individual magnitude distributions must contain at least five consecutive classes with at least three meteors each, the faintest class being at least 2 magnitudes brighter than the limiting magnitude. The width of the magnitude classes is 1. As the $r$-value is deduced from linear regression, the correlation coefficient should be larger than 0.98.

The observations in 1993 concentrated around the maximum. Although a good profile was obtained for the period between December 12 and 15 no reliable $r$-value could be found for the days before and after this period. The first and last value calculated from the 1992 data (at $\lambda_\odot = 260.^\circ44$ and $\lambda_\odot = 262.^\circ31$, respectively) turned out to be almost identical with the figures for the same position in 1991. Therefore, we used the $r$-profile of 1991 (Figure 1 and Table 1 in [2]) to complete the 1993 values since the population index is necessary for computing the hourly rates. The values added are at $\lambda_\odot = 259.^\circ0$ with $r = 2.7 \pm 0.1$ and at $\lambda_\odot = 264.^\circ0$ with $r = 2.5 \pm 0.1$. The profile is shown in Figure 1. The entire profile is smooth with no significant variations, and shows the same general shape as in 1991. Centered at the rate maximum of the shower, the population index $r$ reaches its lowest value. However, the difference in $r$-value between the center and the outer parts of the Geminids is lower than for other major showers (Perseids 1991 and 1992: $r = 2.9$–$1.9$ [3]; Quadrantids 1992: $r = 3.7--2.1$ [4]). This emphasizes the unique constitution of the Geminid meteoroids [5]. This is also obvious in the small portion of Geminid meteors showing train phenomena compared to particularly the Perseids.

## 3. The activity profile

Knowing the change of $r$ with time we are now going to calculate the zenithal hourly rates (ZHR) of the Geminids by the general reduction formula

$$ZHR = \frac{n \times r^{6.5-\mathrm{lm}} \times F}{T_{\mathrm{eff}} \times \cos z},$$

where $n$ is the number of Geminids and lm, $F$, and $T_{\mathrm{eff}}$ are the limiting magnitude, field correction, and effective duration of the observation, respectively. The angle $z$ is the zenithal distance of the Geminid radiant.

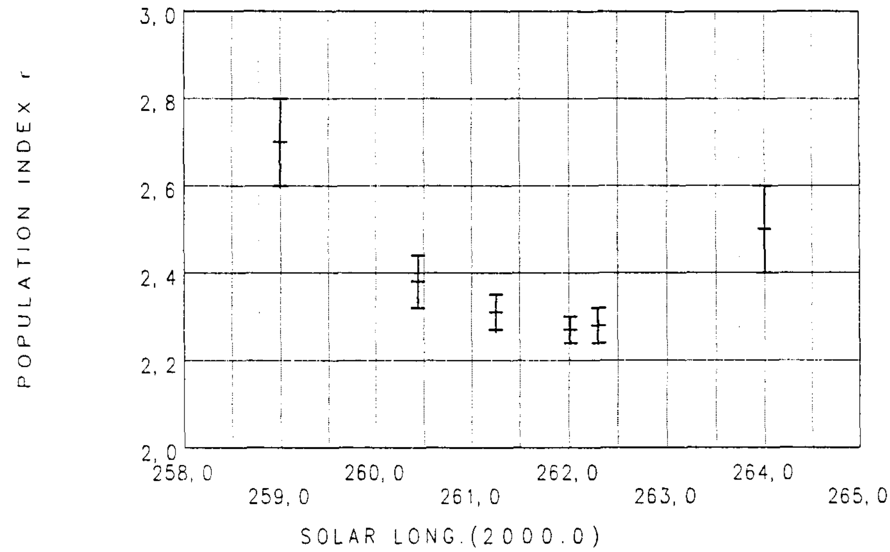


Figure 1 – Profile of the population index $r$ of the 1993 Geminids. The values at $\lambda_\odot = 259^\circ\!.0$ and $\lambda_\odot = 264^\circ\!.0$ were added from the profile of 1991 as the 1993 data did not yield a reliable result.

Table 1 – The population index $r$ of the 1993 Geminids

| $\lambda_\odot$(2000.0) | Obs | Geminids | $r$ | $\overline{\text{lm}}$ |
|---|---|---|---|---|
| 259.00 | 4 | 155 | $2.70 \pm 0.10$ | 5.94 |
| 260.44 | 16 | 1157 | $2.38 \pm 0.06$ | 6.44 |
| 261.26 | 52 | 6086 | $2.31 \pm 0.04$ | 6.31 |
| 262.03 | 92 | 11001 | $2.27 \pm 0.03$ | 6.29 |
| 262.31 | 56 | 5923 | $2.28 \pm 0.04$ | 6.29 |
| 264.00 | 2 | 102 | $2.50 \pm 0.10$ | 6.25 |

Table 2 – Intervals for the averages of the Geminid ZHRs.

| Period | Interval length | Interval shift |
|---|---|---|
| 250°00 – 260°50 | 2°00 | 1°00 |
| 260°50 – 261°55 | 0°60 | 0°30 |
| 261°55 – 261°70 | 0°40 | 0°20 |
| 261°70 – 262°50 | 0°20 | 0°10 |
| 262°50 – 263°00 | 0°50 | 0°25 |
| 263°00 – 270°00 | 2°00 | 1°00 |

The individual ZHR values were averaged over bins given in Table 2. The averages were weighted by the reciprocal correction factor $\cos z/(r^{6.5-\text{lm}} \times F)$.

The choice of the intervals and their lengths depends on the shape of the profile and the number of observational data. Still, many observers concentrate on the near-peak period only. In order to derive a complete profile, Geminid data are required for the entire activity period. Because of the lower numbers of shower meteors, even more intervals would be necessary to obtain good values of $r$ and certain averages of the ZHR. On the other hand, the variations of $r$ and rates seem to be negligible in these branches, and we may average over longer intervals than near the maximum. The choice of the intervals requires us to calculate a first, rough profile, from which the most appropriate splitting is taken.

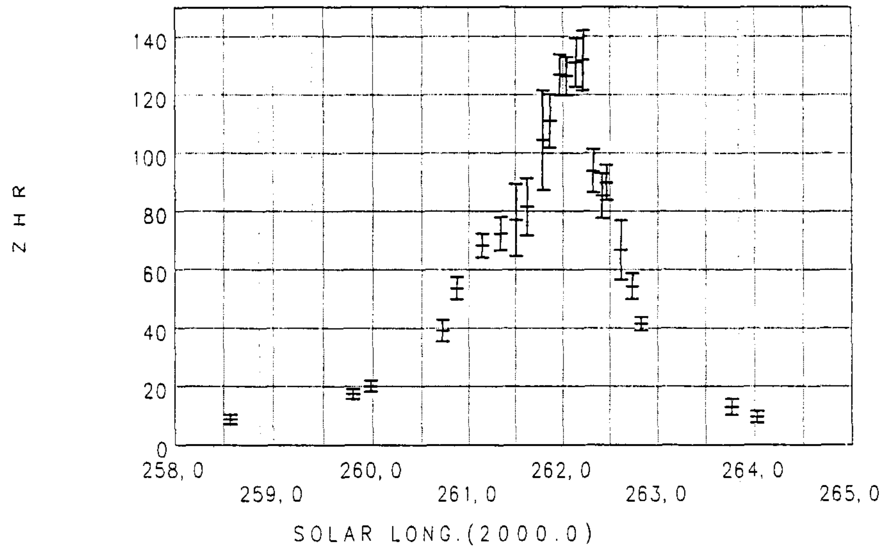


Figure 2 – ZHR-profile of the 1993 Geminids. The values are given in Table 3. The maximum ZHR of $130 \pm 8$ occurs at $\lambda_\odot = 262^\circ\!.1$. The profile is skew as theoretically calculated by Fox et al. [6]

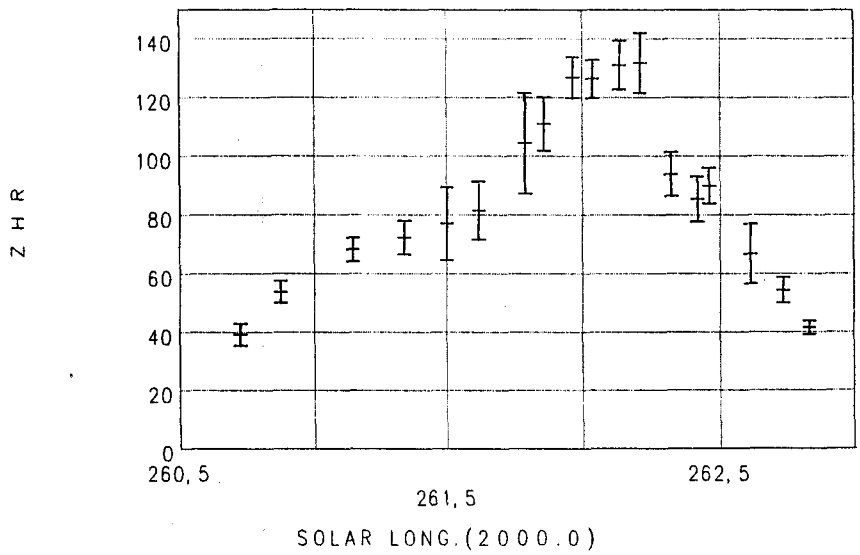


Figure 3 – Detail of the ZHR-profile around the maximum of the 1993 Geminids. In the period between $\lambda_\odot = 261^\circ\!.8$ and $\lambda_\odot = 262^\circ\!.3$ the ZHR exceeds 100. This may be regarded as a kind of ZHR plateau with relatively small rate variations.

When averaging the ZHRs, the procedure rejects outliers which lie off the mean by more than $1.645\sigma$, i.e., values which lie outside a confidence interval of 90%.

In recent analyses, we tried to compensate systematic errors by deriving personal perception coefficients. These factors were obtained from the average offset of one observer's rates from the mean ZHR in certain periods. The periods should show relatively constant activity or, at least, a monotonic behavior with a slight slope. The 1993 Geminid data concentrated near the maximum; there is little chance to find a period fulfilling the above criteria. We are actually dealing with slopes in both directions. Other periods would include a tiny minority of the observers participating. Therefore, we did not apply perception coefficients to the activity profile. This again underlines the necessity to not restrict observational efforts to the maximum night, but to cover also the other periods.

In Figure 2, we show the complete activity profile obtained from the 1993 observations. The shape of the profile looks very much like the theoretical profile calculated by Fox et al. [6]. Furthermore, it is smoother than the 1991 profile [2]. This may be partly due to the above described effects of the perception coefficients. Figure 3 clearly shows that there is a period of several hours length in which the high ZHR varies rather little. This kind of plateau has been found in previous analyses as well (e.g. [2]).

Table 3 – ZHR-profile for the 1993 Geminids. The Geminid rates based on the $r$-values given in Table 1. Int. gives the number of available intervals, GEM lists the number of Geminid meteors included in the respective sample. For comparison, the number and hourly rate of sporadic meteors in the same intervals is given as well. $r$ refers to the used population index for the intervals and is interpolated from the profile determined first.

| $\lambda_\odot$ (2000.0) | Int | Gem | ZHR | Spor | HR | $\overline{\mathrm{lm}}$ | $r$ |
|---|---|---|---|---|---|---|---|
| 255.154 | 11 | 27 | 4.4 ± 1.6 | 96 | 16.6 | 6.12 | 2.70 |
| 255.519 | 25 | 54 | 4.2 ± 0.8 | 198 | 16.1 | 6.02 | 2.70 |
| 255.947 | 19 | 37 | 4.1 ± 0.7 | 142 | 16.8 | 5.92 | 2.70 |
| 257.632 | 15 | 62 | 8.8 ± 2.3 | 155 | 21.6 | 6.04 | 2.70 |
| 258.569 | 29 | 158 | 8.8 ± 1.6 | 336 | 18.0 | 6.51 | 2.69 |
| 259.791 | 102 | 1072 | 17.5 ± 1.7 | 883 | 14.0 | 6.33 | 2.51 |
| 259.974 | 84 | 971 | 20.1 ± 1.9 | 681 | 13.6 | 6.24 | 2.46 |
| 260.724 | 42 | 731 | 39.2 ± 3.7 | 413 | 22.0 | 6.23 | 2.35 |
| 260.871 | 87 | 2583 | 53.7 ± 3.8 | 900 | 19.5 | 6.24 | 2.34 |
| 261.146 | 82 | 3737 | 68.2 ± 4.1 | 987 | 17.7 | 6.28 | 2.31 |
| 261.341 | 43 | 2224 | 72.2 ± 5.7 | 559 | 17.1 | 6.31 | 2.30 |
| 261.503 | 6 | 339 | 77.0 ± 12.4 | 59 | 13.3 | 6.35 | 2.30 |
| 261.622 | 9 | 376 | 81.5 ± 9.9 | 111 | 24.2 | 5.96 | 2.29 |
| 261.791 | 12 | 573 | 104.4 ± 17.2 | 203 | 36.0 | 6.54 | 2.28 |
| 261.861 | 36 | 1460 | 111.0 ± 9.2 | 477 | 35.1 | 6.49 | 2.28 |
| 261.968 | 86 | 2960 | 126.9 ± 7.0 | 625 | 22.7 | 6.23 | 2.27 |
| 262.039 | 118 | 4031 | 126.4 ± 6.5 | 663 | 17.1 | 6.13 | 2.27 |
| 262.135 | 109 | 3834 | 131.1 ± 8.3 | 554 | 15.1 | 6.20 | 2.27 |
| 262.212 | 70 | 2747 | 131.8 ± 10.2 | 414 | 15.3 | 6.20 | 2.27 |
| 262.323 | 23 | 1204 | 93.9 ± 7.5 | 210 | 15.9 | 6.15 | 2.28 |
| 262.418 | 11 | 483 | 85.3 ± 7.7 | 85 | 14.6 | 6.26 | 2.29 |
| 262.461 | 4 | 96 | 89.9 ± 6.1 | 43 | 38.9 | 6.10 | 2.30 |
| 262.614 | 31 | 931 | 66.7 ± 10.2 | 500 | 28.0 | 6.37 | 2.31 |
| 262.732 | 66 | 1593 | 54.3 ± 4.4 | 955 | 27.7 | 6.37 | 2.33 |
| 262.832 | 36 | 690 | 41.5 ± 2.3 | 465 | 27.6 | 6.35 | 2.35 |
| 263.770 | 15 | 95 | 13.0 ± 2.7 | 219 | 31.2 | 6.40 | 2.45 |
| 264.029 | 22 | 111 | 9.6 ± 2.0 | 333 | 29.6 | 6.39 | 2.47 |
| 265.075 | 17 | 34 | 4.1 ± 0.8 | 180 | 22.5 | 6.12 | 2.50 |
| 265.642 | 14 | 31 | 3.8 ± 1.0 | 110 | 13.0 | 6.28 | 2.50 |
| 266.198 | 4 | 13 | 3.0 ± 1.3 | 44 | 9.4 | 6.64 | 2.50 |

## 4. Conclusions

The 1993 Geminid return did not show peculiarities. There occurs a kind of plateau ZHR ($\lambda_\odot = 261.^\circ8$ to $\lambda_\odot = 262.^\circ3$) with a maximum centered at $\lambda_\odot = 262.^\circ1$.

The peak ZHR is 130 ± 8, and is thus somewhat higher than the peak rates observed in the previous years. For comparison, in 1991 a maximum ZHR of 110±10 was observed at $\lambda_\odot = 262.^\circ3$ [1]. The shape of the profile is very similar to the theoretical profile derived by Fox et al. [6].

We found that the introduction of perceptions derived from near-peak intervals only is not appropriate. On the contrary, these perceptions may lead to apparent structures. Perhaps this happened in the 1991 analysis [2], where a more rough profile has been derived after the perceptions were included. A revision of the detailed data may bring further light into the application of the perception coefficients.

We urgently ask all observers to watch the shower also in the nights before and after the maximum. We know that December nights are not the most pleasant ones to sit outside–but it will be worth the effort. The last conclusion, however, holds for each shower for which a profile analysis is intended.

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## Fireballs and Meteorites

# The Daylight Fireball over the North Sea

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

*F. Bettonvil, M. Neijts, and B. Apeldoorn*

Results on trajectory, radiant, and orbital calculations of an extremely bright fireball, which appeared over the North Sea on May 29, based on eye-witness reports, are presented.

As was already communicated to WGN by our Dutch meteor-colleague Casper ter Kuile [1], the Sunday morning of May 29, 1994, turned out to be an exceptional one. At about $9^h32^m$ UT, a dazzling fireball appeared in the Western sky as seen by eye-witnesses in the Dutch provinces of North- and South-Holland, Zealand, and Friesland. Soon after the first reports, during the afternoon of that same day, we started a first investigation at addresses in North-Holland, mainly situated around the town of Alkmaar, meanwhile collecting more reports by telephone at local police-offices and editorial offices, coast guards, and meteorological stations. In total, about 80 reports were collected.

According to the first measurements of azimuth and elevation at a number of locations, carried out that same Sunday afternoon, it soon turned out that the fireball's trajectory was entirely situated above the North Sea. As Casper ter Kuile already described, the brightness of the meteor indeed reached tremendous values. The apparent magnitude was at least $-15$. Magnitude $-20$ is very likely, in particular for the last and brightest part of the meteor. Of course, these estimates, after all on the basis of layman reports, represent very rough values.

During the following days we selected a number of eye-witnesses who observed the meteor's trajectory with more or less sufficient accuracy, i.e., with respect to fixed points such as church towers or windows, and paid them a visit. Besides the measurements (azimuth, elevation), all eye-witnesses were asked for the estimated duration (important to get an idea about the velocity), angles of the trajectory with respect to the horizon, and other phenomena such as colors, flares, disintegration, etc. Of special interest is the "dust" trail to which the greater part of the observers referred. The (wind-blown) trail had a white or grayish hue and remained visible for almost 15 minutes.

In the press, we made a call to people who might have captured the fireball or the dust-trail by sheer accident on video-tape or film. This was a lucky shot. An observer near the village of Anna Paulowna photographed the trail shortly after the appearance of the fireball (Figure 1). This provided us with an accurate "pin-point" position with respect to the visual results.

On the basis of all data, available at the end of July, the results are as follows:

- The meteor entered the Earth's atmosphere from the ENE at an angle of 50° with respect to the horizon (Figure 2), traveling in WSW direction with a speed of $(16 \pm 5)$ km/s.
- The end point of the luminous trajectory was located at a height of $(25 \pm 10)$ km above sea level at $\varphi = 52°38' \pm 02'$ N and $\lambda = 02°56' \pm 04'$ E; the starting point (very uncertain) at a height of 45 km at $\varphi = 52°42'$ N and $\lambda = 03°10'$ E.
- The relatively small terminal height and atmospheric velocity, combined with the extraordinary magnitude of this fireball, suggests the dropping of meteorites in the North Sea, just halfway between the coasts of the United Kingdom and the Netherlands.
- The orbital inclination $i$, of course depending on the true velocity, is most probably 9° ($v = 16$ km/s).
- The apparent radiant is situated at $\alpha = 92° \pm 8°$ and $\delta = +53° \pm 8°$ (eq. 2000.0), which is close to the borders of the constellations Auriga, Lynx, and Camelopardalis.

Figure 1 – Photograph of the dust trail made by L. Keizer at Anna Paulowna, 1 minute after the fireball.

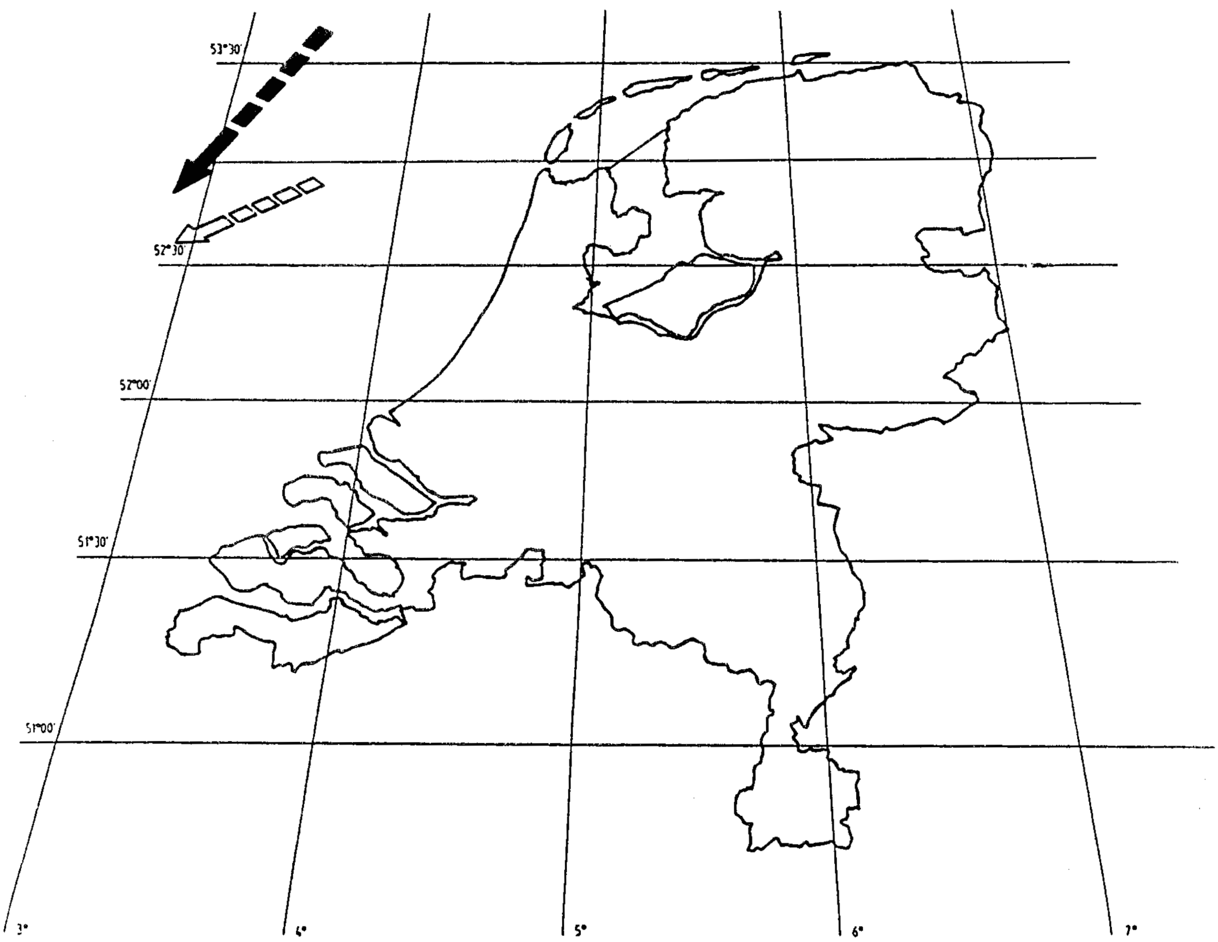


Figure 2 – Trajectory of the fireball which appeared completely above the North Sea. The first—dashed—part of the trail is only observed by a few people.

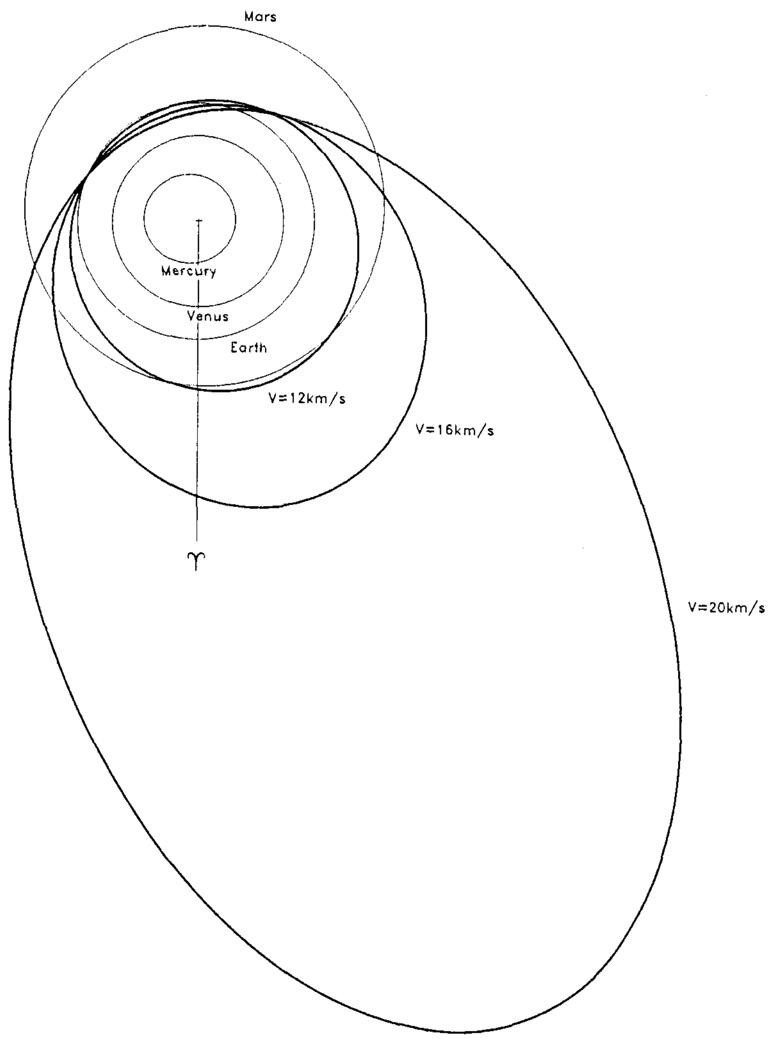


Figure 3 – Orbit of the fireball for observed velocities of 12, 16, and 20 km/s.

Based on three different velocities the orbital elements are as shown in Table 1.

Table 1 – Orbital elements.

| Velocity | 12 km/s | 16 km/s | 20 km/s |
|---|---|---|---|
| $\omega$ | 146° ± 8° | 138° ± 8° | 135° ± 8° |
| $\Omega$ | 67°.9 | 67°.9 | 67°.9 |
| $i$ | 2°.4 ± 1°.7 | 9° ± 3° | 12° ± 4° |
| $q$ | 0.99 ± 0.01 AE | 0.92 ± 0.03 AE | 0.89 ± 0.04 AE |
| $a$ | 1.24 ± 0.05 AE | 2.0 ± 0.4 AE | 4 ± 3 AE |
| $Q$ | 1.49 ± 0.09 AE | 3.0 ± 0.7 AE | 7 ± 6 AE |
| $e$ | 0.20 ± 0.02 | 0.53 ± 0.07 | 0.8 ± 0.1 |

These data may indicate an asteroidal origin. Assuming a velocity of 16 km/s, a density of 2.5 g/cm$^3$, an absolute magnitude of −20, and a ratio of 0.1–1% between the visual light and the total amount of released kinetic energy [2,3], the initial mass of the meteoroid was anywhere between 40 and 400 metric tons. One of our members exposed several pieces of adhesive tape in the open air to try to capture microscopic material of the fireball during the days after the appearance [4]. So far the results are unknown.

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# Observational Results

## JAS Meteor Section Results: 1993 November–December

*Alastair McBeath*

An overview of results forwarded to the *JAS Meteor Section* for 1993 November and December is presented. The Geminid maximum on December 13-14 was particularly well-covered, and a photographic radiant determination was possible on this night.

### 1. Introduction

November's skies were poorer than October's, but eleven visual observers reported 106 meteors in 29.66 hours, and two photographers produced 35.3 hours of exposures for 23 trails (including 15 Leonids) in addition. The observers for November, in the UK unless noted, were as follows:

Charlotte Bland, Shelagh Godwin, Valentin Grigore (Rumania), Richard Livingstone, Tony Markham, Michael Maunder, Tom McEwan, Graham Pointer, Ian Rigney, Alan Smeaton (Germ.), Roy Watson.

December was very good, and 2468 meteors (1943 Geminids) were seen in 61.57 hours. Eighteen observers reported data, both photographic and visual, the camera hours tally not far behind the visual ones, thanks to several observers operating more than one camera, at 51.22 hours. In total, 47 trails (39 Geminids) were obtained. December's observers included the following persons:

Charlotte Bland, Peter Craven (Finland), Dave Gavine, Shelagh Godwin, Ian Gray, Valentin Grigore, Antoine Grima (Malta), Paul Hayworth, Terry Holmes, Tony Markham, Michael Maunder, Alastair McBeath, Tom McEwan, T. Oldroyd, Ian Rigney, George Spalding, Chris Watson, Roy Watson.

### 2. November results

Watch lengths were kept short for most people thanks to some typical UK November weather, but even in Rumania, Valentin Grigore had problems with poor conditions. Low visual Leonid rates were detected on several nights in mid-month, but the hoped-for upturn in their activity in advance of their parent comet Tempel-Tuttle's return in about five years time, seems not to have taken place as yet. Observations reported elsewhere appear to bear this general statement out. Taurids too were apparent on many watches, providing their normal low hourly rates. The numbers of reliably seen meteors in clear skies were too small to allow further analysis.

### 3. December results

Visual watches were carried out on eleven nights in December, including every night from December 10-11 to 18-19 inclusive, right over the Geminid maximum. Not every night provided conditions suitable for computing ZHRs however, but the more reliable mean ZHRs from sites with a limiting magnitude of at least +5.5 and where less than 20% cloud cover was present are given in Table 1.

Table 1 – Mean Geminid ZHR values.

| Date | ZHR | Error |
|---|---|---|
| December 07-08 | 4.0 | 2.8 |
| December 10-11 | 13.2 | 6.6 |
| December 11-12 | 12.4 | 5.0 |
| December 13-14 (pre-midnight) | 98.5 | 14.9 |
| December 13-14 (post-midnight) | 82.3 | 12.3 |
| December 16-17 | 7.1 | 3.8 |
| December 17-18 | 3.0 | 0.8 |
| December 18-19 | 1.5 | 0.8 |

Table 2 – Global magnitude distributions for the 1993 Geminids and December sporadics.

| Magnitude | $-3^-$ | $-2$ | $-1$ | 0 | +1 | +2 | +3 | +4 | $+5^+$ | Tot | $\overline{m}_{6.5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Geminids | 19 | 20 | 43 | 104 | 126 | 165 | 184 | 80 | 25 | 766 | 2.4 |
| Sporadics | | | 1 | 13 | 22 | 46 | 77 | 52 | 22 | 233 | 3.5 |

Table 3 – Global train breakdown for the 1993 Geminids and December sporadics, giving numbers ($N$), percentages (%), and mean durations in seconds ($D$).

| Magnitude | $-3^-$ | $-2$ | $-1$ | 0 | +1 | +2 | +3 | +4 | Tot |
|---|---|---|---|---|---|---|---|---|---|
| $N$ Gem | 12 | 7 | 17 | 14 | 4 | 0 | 1 | 0 | 55 |
| % Gem | 63 | 35 | 40 | 14 | 3 | | 1 | | 7.2 |
| $D$ Gem | 2.6 | 1.6 | 0.7 | 0.7 | 0.6 | | 0.5 | | |
| $N$ Spor | 0 | 0 | 1 | 2 | 1 | 6 | 1 | 1 | 12 |
| % Spor | | | 100 | 15 | 5 | 13 | 1 | 2 | 5.2 |
| $D$ Spor | | | 1.0 | 0.5 | 1.5 | 1.4 | 0.5 | 0.5 | |

Tables 2 and 3 present magnitude and train data for the Geminids and December sporadics, again based solely on clear sky watches, from the UK only. The mean limiting magnitude for this data was +5.8.

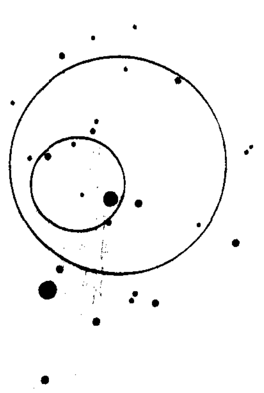

Figure 1 – Photographic Geminid radiant position.

With so many photographs obtained on December 13-14, most of these being Geminids, and of good quality, it has been possible to derive a preliminary photographic radiant position for the shower using nine trails. Figure 1 shows the areas defined by the trail intersections, beside the bright star Castor ($\alpha$ Geminorum) in Gemini. The small circle is where most trail intersections occurred, and is about 3° in diameter (center at $\alpha \approx 115\overset{\circ}{.}5$ and $\delta \approx +32\overset{\circ}{.}5$), while the larger circle encompasses all the potential radiant points, and has a diameter of about 7° (center at $\alpha \approx 114°$ and $\delta \approx +33°$). The predicted visual radiant on December 13-14 from the *IMO*'s working list of showers is at $\alpha = 112°$ and $\delta = +33°$, with a diameter of about 4°, so both of these photographic plots are reasonably close matches, certainly within the margins of error involved in the measurements of the trails. A reasonably good spread of trail orientations around the radiant region should ensure these errors are not more than 3°–4° at maximum, and result chiefly from problems in the astrometric measurements.

December 13-14 was an exceptional night for visual observers too, with several observers recording well over 100 meteors in just a few hours. The two best watches of the night were by Valentin Grigore at Tirgoviste in Rumania, with 799 meteors (700 Geminids) in $7^{\mathrm{h}}\!.75$, and by Alastair McBeath from Morpeth in England—451 meteors (367 Geminids) in $6^{\mathrm{h}}\!.5$.

Peak mean Geminid ZHRs were roughly 100 before midnight UT, falling slightly to around 80 afterwards, but observed rates from the best sites (limiting magnitude between 6.2 and 7.1) were between 100–130 at times, and using data from such places alone indicates maximum individual ZHRs close to these observed values.

Twenty-nine Geminid fireballs were observed from all locations, the best of which was a superb magnitude −10 purple event, witnessed at $2^{\mathrm{h}}16^{\mathrm{m}}$ UT on December 13-14 by Valentin Grigore. This left a 35-second naked-eye train, but with binoculars, the train remained visible for nearly 3.5 minutes, twisting into almost a figure-of-eight shape before fading away.

### Acknowledgments

As ever, I am indebted to all of the observers who contributed data to make this report possible. I am particularly grateful to the photographers, whose efforts have meant that for the first time, a photographic radiant position has been obtained for the Geminids by the *JAS Meteor Section*.

# The 1993 Geminids in Southern Bulgaria

*Atanas Gavrailov and Roman Chakarov*

An overview of the authors' Geminid observations are given. High activity was seen.

For the observation of this shower, we decided to organize an expedition to a mountain. It was held from December 11 to 14 in the mountain resort of Beli Brezi, 30 km from Kurdjali. The weather was bad on December 11 and 12, so we could not observe then. Fortunately, in the morning hours of December 13, the sky cleared up. With variable limiting magnitude between 5.5 and 5.7 we observed the shower and recorded high numbers of meteors during the short observation period. The ZHR value was around 90. There were not many bright meteors, but "enough."

The night of December 13 was clear and the limiting magnitude stayed comparatively good—6.0. We were amazed by the very strong activity which was much higher than the average (according to the *IMO Meteor Calendar* the ZHR is 110 around maximum). The ZHR increased at the end of the night up to 180. The number of bright meteors was also very striking. We saw a few especially bright meteors that were trained. The most magnificent one was a −6 Geminid fireball. It showed two explosions, a blue color and a short train.

### Editor's comment

*When evaluating a shower's strength, it is important to take into account individual observers' perceptions. In a larger group of observers, it is not uncommon that the most perceptive observer sees twice the number of meteors of the least perceptive observer!*

# The International Meteor Organization

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## Brandenburg, Germany, September 14–17, 1995

The 1995 International Meteor Conference will take place near the historical city of Brandenburg, in the German state with the same name.

The location of the 1995 *IMC*, not so far from Berlin, should allow both West- and East-European observers to participate in large numbers.

In the present issue of *WGN* you can find a pre-announcement of the 1995 *IMC*. Please look out for the December issue which will contain more concrete information as well as a registration form.

Do not miss this unique opportunity to communicate your results, to learn from other meteor workers, and to meet your fellow-observers!

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

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