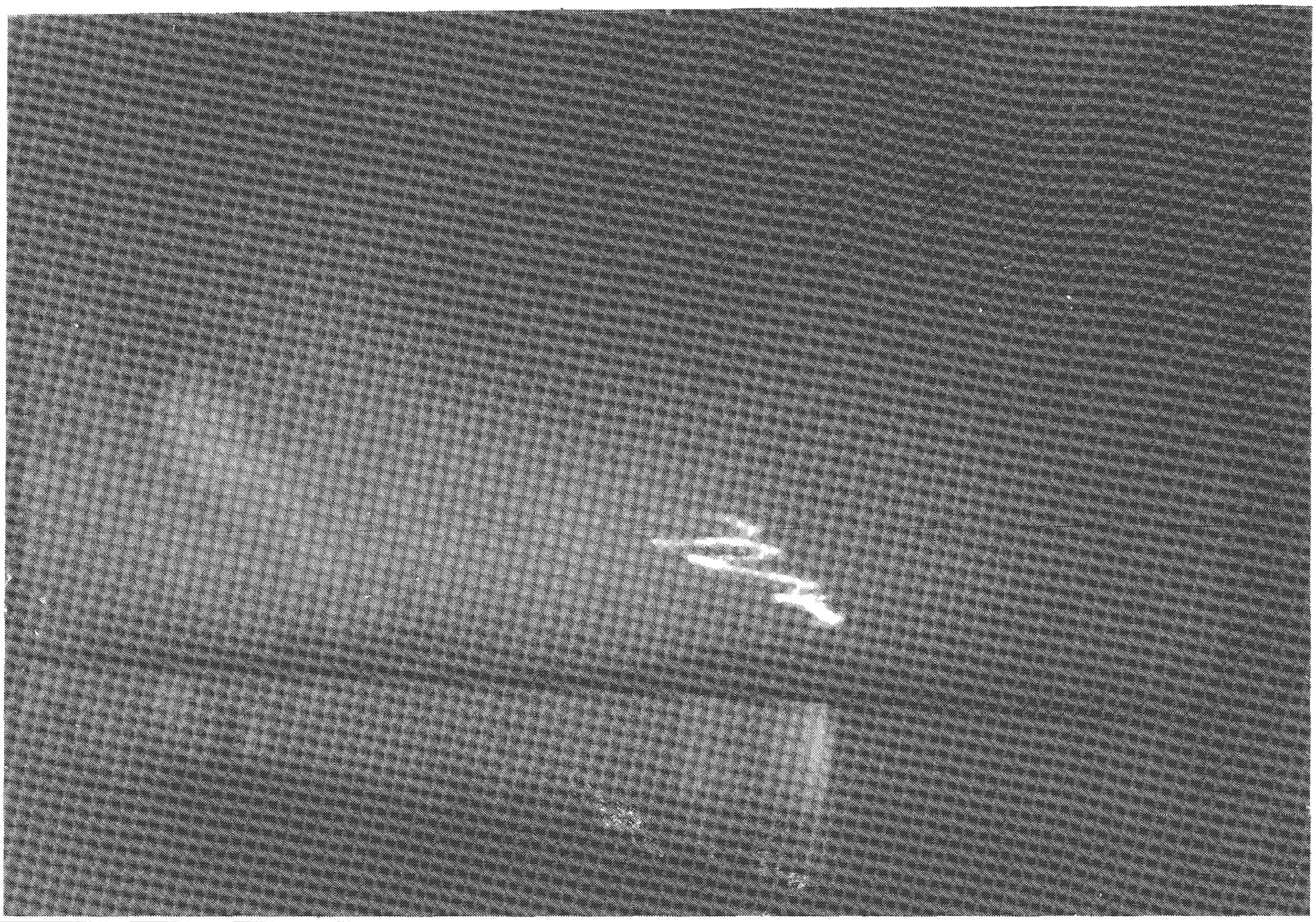
wgn

17 – 6
december 1989

bimonthly journal of the international meteor organization



Fireball dust train photographed during dusk at the Amur River in the Khabarovsk Territory, USSR, on October 7, 1982 (photograph presented by the Committee on Meteorites of the USSR Academy of Sciences and kindly communicated to us by Dr. A. Terentjeva).

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WGN, volume 17, nr 6, December 1989, pp. 197–274

Contents

Useful Information

The February Issue *(WGN 18:1)*

It is anticipated that this issue will be mailed during the first week of February. Of course, you will only receive it if you have paid your dues for 1990! Articles are due *January 10*. They should be sent to *Marc Gyssens* or to any member of the editorial board (addresses on the inside of the back cover).

From the Editor-in-Chief

Marc Gyssens

The International Meteor Weekend in Balatonföldvár, Hungary was a success. Many new contacts were established, especially with and between meteor workers in Eastern Europe. The climax of the event was of course the Founding Assembly of the International Meteor Organization, at which occasion the elected Council took over the management from the Provisional Administration. In some respect, the IMO Founding Assembly was the conclusion of a chain of rapidly succeeding events which led to the organization of international meteor work on a global scale. In most other respects, however, it was just the start of much more work to come. The structures are there now, but they are only an instrument, not a goal; it is up to meteor workers all over the world to use them as efficiently as possible to contribute to the rapid progress of meteor astronomy. This will require a lot of efforts from everybody involved, but the results to be anticipated will make this effort more than worth-while. May 1990 be the start of a brand new era in our branch of astronomy that will give a lot of satisfaction to meteor workers wherever they live, amateurs and professionals alike. In this spirit, I wish you happy holidays and the very best for the year(s) to come!

IMO Contributions/WGN Subscriptions for 1990

Marc Gyssens and Ann Schroyens

This is the very last issue of WGN you receive unless you renew your *IMO* membership and/or *WGN* subscription for 1990. Of course, many readers already did this, and we thank them for their continuing support and confidence. Some others, however, may have forgotten about it, and if you are one of them, please take a moment of your time to do the necessary. You do a service to yourself because your supply of quality meteor information will not be discontinued; and you do us a favor by helping us to compile as quickly as possible a complete mailing list for next year. Going back and forth to the post office to send out back issues to late renewers is a time consuming job; help us by allowing us to spend this time more efficiently!

Everything you need to know about renewing your membership/subscription can be found in the *October issue*, pp. 169–170.

Letters to WGN

compiled by Marc Gyssens

A double Perseid maximum in 1988?

Some more reactions reached us on the article in WGN 17:4, pp. 127–137, several of which are from professionals.

In *WGN* 17:4 you reported the Perseid bimodality. To my mind it is a very interesting and actual publication. I was very impressed by the discussion of the subject in *WGN* too. I have also some private communications about the Quadrantid bimodality, and I now think that many showers have two maxima.

Galina Ryabova, Tomsk State University, October 22, 1989

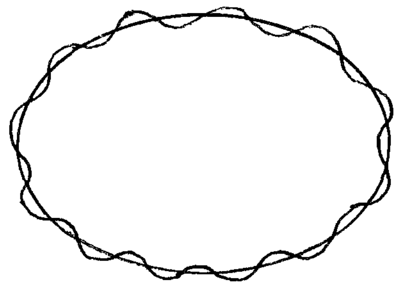

Figure 1 — A single particle path.

As regard hollow meteor streams, I think it is an artifact of the model in some ways but it is also in some sense real. If we take a single particle, then planetary perturbations will cause the particle to move on a sinusoidal curve about the Kepler orbit. The particle orbit can be in three dimensions, i.e. out of the plane of the paper. Considering many particles, we have many orbits like the curve on the picture. As with all sine waves, particles spend most time at the extremities. Thus if the stream is represented by a small number of particles (< 100) a significant number will be at their extremity, and taking a picture of the cross section, one finds many particles on a near maximum, and few between.

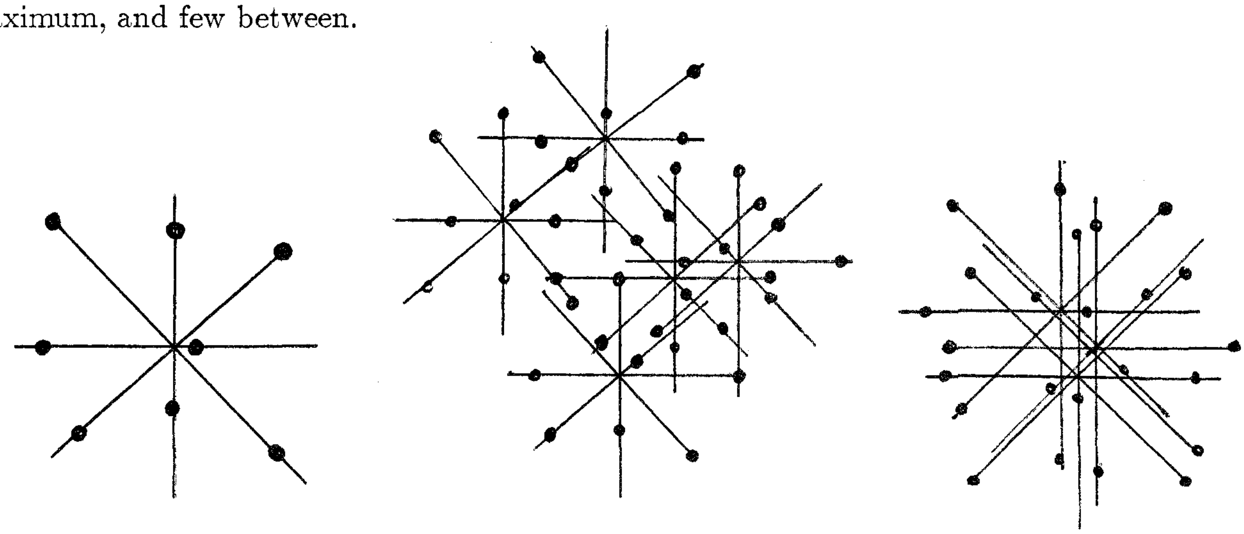

Figure 2 – *Left:* single wave seen end-on. *Middle:* family of orbits. *Right:* family of orbits if oscillation is greater than spread on orbits.

This looks hollow and to some extent it is (Figure 2, left). The whole effect is lost if instead of one orbit there is a family of orbits (Figure 2, middle). The effect can be retained if oscillation is greater than the spread of the orbits (Figure 2, right). Care is needed in interpreting any numerical model.

I.P. Williams, Queen Mary College, August 1989

Due to the distrust of visual observations we have to be most careful in observing and analyzing. Now it is better to publish no assertion than an uncertain one.

Looking at Figure 1, p. 130 there are striking dips at $\lambda_\odot = 135\overset{\circ}{.}6, 138\overset{\circ}{.}4, 139\overset{\circ}{.}4, 140\overset{\circ}{.}5, 141\overset{\circ}{.}5, 142\overset{\circ}{.}6$. Before interpreting the dip at $139\overset{\circ}{.}4$ as a double maximum one has to elucidate the regular occurrence of significant dips.

I calculated the altitude of the radiant for the first American observations at $\lambda_\odot = 139\overset{\circ}{.}13$. It was about 13° in Florida (82° W, 28° N)! Because of the uncertainty of the zenith correction factor, this ZHR is unreliable. I think we should make no assertion at this moment than one based on such reliable observations. I fully agree with Christian Steyaert in the point that no personal impressions are of value in proving high or low activity. We should prove our conclusions by means of observational data and avoid a mixture with personal impressions. Such impression reports are important for encouraging observers but they should be published apart from shower analyses.

I think it is possible to detect variations of activity also in a time span of few hours if there is a sufficient number of reliable observations.

Ralf Koschack, September 10, 1989

We also received two more reactions on the remarkable trains reported in WGN 17:4, pp. 115–116, one from Trond Erik Hillestad and the other from Pekka Parviainen. Since the latter one contains an interesting photograph we would like to reproduce in WGN, we postpone these two letters to the following issue.

The 1989 IMW in Hungary and the Founding Assembly of IMO

Paul Roggemans

Since the first ideas to establish *IMO* were discussed in 1987, a lot of preparing work has been done to guide *IMO* towards its first General Assembly. Founding an ordinary, national society implies a lot of work. The degree of complexity for an international organization is still more impressive. All details were carefully studied, thereby involving the 97 founding members of *IMO*. A Constitution, a Council and commission programs were prepared. 97 founding members and 26 associate members were invited to attend the Founding Assembly at the International Meteor Weekend on October 5 at Balatonföldvár in Hungary. This meeting represented a milestone in the history of amateur meteor work; this article is meant to inform the people absent in Hungary, and to give them an idea about these very important days.

1. Visit to Kötsce

Evelyne Blomme, Olivier Talvat, Marc Gyssens and the author arrived at Budapest the first day of October. Tamas Kalmar awaited us and brought us to his house where we found Jürgen Rendtel, André Knöfel, Ralf Koschack and Rainer Arlt. This was the start of the final *IMO* preparations. After a good lunch offered by the family of Tamas, our Hungarian friends organized the trip to Kötsce by car. Kötsce is a very small village where *MACSIT* runs an old farm house, now installed to house amateurs that observe at the site. The first night the author and the East German team observed together. This was interesting to compare the observing methods. In theory, all *IMO* members use the same instructions, but few of them have observed together. Fatigue kept other people sleeping the first night and more people were expected the next day.

Daytime was used to discuss all kind of technical details, and to to write up the final *IMW* program; nighttime was used for some observations. The sky was dark and as good as an average good night in the Haute-Provence. More and more people arrived these days: Malcolm Currie, Dieter Heinlein, Detlef Koschny, Alexandra Terentjeva, Gennady Andreev, Casper ter Kuile and many others. The time all these people were together was very well used. As the group lived together a few days, the *IMO* people attained a good level of cooperation. The European membership of *IMO* was really well represented.

2. The IMW at Balatonföldvár

On October 5, we moved to Balatonföldvár where the *IMW* was to be held; we arrived at "Hotel Festival" after a good walk. Indeed, the *IMW* was organized at a rather large tourist hotel. For many people it was their first visit to Hungary; one thing they experienced is that Hungarian wine is excellent!

Finally, the 1989 *IMW* was opened. In this report we will not describe each lecture; the proceedings of this *IMW* will be published in 1990.

After dinner, there was a first Council meeting to prepare the Founding Assembly. Several important principles were discussed, some of which are of interest to all readers. First, it was agreed that each Council member is assumed to have an active job in *IMO*; in this way, lazy people will be discouraged to seek Council membership. Furthermore, it is important to realize that international work needs priority over national activities when a choice has to be made. It is also good news that the Council members agreed to pay themselves expenses of some personal character, such as correspondence, phone, ..., thus helping to keep *IMO* membership fees low. There will be observational reports (e.g. on an annual basis), and subsequent *IMW*-*IMO*-meetings will be held annually basis, making *IMO*-meetings abroad Europe a distinct possibility. *IMO* will get local representatives, about one for each language group.

October 6 got a morning program with lectures and a fine afternoon excursion. The group crossed Lake Balaton with a ferry and drove into the countryside to relax a bit in the surroundings of the historic town of Tihany. Cosy cafés and a long walk, showing the participants some geological particularities of the area, provided an opportunity for many hours of informal talk. The trip was a rather improvized one, using all the available cars. A Czech group crossed the border in a small truck which eventually turned out to be the means of transportation for about 20 people at the excursion! The evening got a workshop on databases and associated computer stuff. Reports on the workshops will be included in the proceedings by the chairmen of the commissions.

The observational databases are well defined now and already exist for some time. It is important that all people willing to cooperate in *IMO* make an effort to respect international standards. *IMO* does not want to renegotiate its standards to adapt them towards any new group that wants to join in. The first standards were discussed at the 1986 *IMW* and further developed through correspondence. The 1989 *IMW* can be considered as their final confirmation.

3. The Founding Assembly

October 7 was well filled with 11 lectures followed in the late afternoon by the Founding Assembly of the *International Meteor Organization.*

Opening chairman of this happening was Marc Gyssens who acted on behalf of the Provisional Administration. This historical event was attended by a large number of people, both members and non-members. By common agreement, the birthday of *IMO* had been set at May 1, 1988, after a first six months of preliminary preparations. October 7, 1989 is the end of the founding period and the start of the existence of *IMO* as a constitutional association. At this occasion, it seemed a good idea to the present author to review the backgrounds and ventures that led to the current *IMO*.

It is important to know that *IMO* is not born from a recent initiative; it is the product of a ten year long evolution of international cooperation among meteor workers. The organization has three main roots: the *International Meteor Weekends*, the journal *WGN*, and an intensive correspondence among meteor workers. The tradition of *IMW*s started in West Germany after a successful *International Astronomical Youth Camp* in 1978. The first Meteor Seminar took place in June 1979 in Königswinter (FRG). The second Meteor Seminar was organized by Hans Georg Schmidt in November 1980 in Pullach (FRG) and it drew a very international audience. Already at that time, a European observing method was presented to become a standard. It was used by most groups and served as a basis for the current *IMO* method. A first attempt was made to establish an international meteor body, resulting in *FEMA*. It never got off the ground really well, as not everyone agreed on its necessity. It was a very lose framework of independent groups, without a constitution and without a real management. It silently died away a couple of years later.

Part of the problems then in establishing international cooperation lies in the fact that there have always been two types of meteor observers: those who watch meteors for pure fun and those who make systematic observations with a scientific goal in mind. Indeed, the first group of people really does not need an organized international cooperation, since it is of no use to them. In the period 1980-1985 both types of amateurs took part in all activities and as a consequence a lot of irrelevant talk on observing motivation consumed far too much of the meeting time. The stargazers dominated a long time in meteor work, preventing this field of astronomy from getting rationally organized. Meteor Weekends were held in 1982 in Hasselt (Belgium), in 1983 in Denekamp (the Netherlands) and in 1985 in Violau (FRG). Cooperation improved, but no organization was established.

Up to 1981, *WGN* had served as a regular newsletter for Dutch speaking meteor observers. It grew from a leaflet in 1973 to a bimonthly periodical with issues of 40 or more pages. In view of the growing number of foreign contributions and the rapidly expanding international readership, it was decided in 1981 to publish all relevant information in English. Although this decision was not appreciated by part of the Dutch speaking readers, it was of course greatly welcomed by all foreign readers. Contributions came mainly through the intensive correspondence of the editor at that time. Meteor work aimed at the scientific aspect of the topic was encouraged, a policy that created a selective readership.

Since 1984, regular meteor observing camps at Puimichel (France) brought together several of the most active West European meteor observers, right at the observing field. The excellent skies and large quantities of observational data required a very rational method. Experimental methods of data reduction led to the current *IMO* standard, which was about at its current format in 1985. The 1986 meteor expeditions in Puimichel used the current forms, already adapted in detail for fast data storage in a future *VMDB*. The English edition of a *Handbook for Visual Meteor Observations* was also prepared in 1986 and so was the 6th Meteor Weekend. *WGN* got more foreign subscribers than ever before, since it became the *International Circular for Meteor Observers* in 1985.

All the elements were present to make a serious step towards standardization at the 1986 *IMW* at Hingene (Belgium). This weekend was a very successful event with many participants from various areas in Europe. It was the first such meeting where international cooperation could be thoroughly discussed. During an evening debate it turned out that still some people did not want to see meteor astronomy really organized. The majority finally agreed on a standard for visual observing, a ZHR definition and the establishing of an international database. It was agreed to describe this method in a handbook to spread and to generalize the observing standards. However, collection of results, archiving reports, and recognition by astronomical societies still required a more concrete organizational structure.

In 1987, *WGN* ceased publishing articles in Dutch and became an international bimonthly journal in English. In November 1987, the Belgian meteor observers who produced *WGN* started to negotiate about the feasibility of an *IMO*. The response that came in can be read in *WGN*s of 1988. The consultation of many people learned that a large majority was in favor of such an *IMO*. A first concrete proposal was prepared and presented at the *IMW* in Oldenzaal, March 1988. Several people came to this meeting hoping that *IMO* would be finally started. While the large majority of meteor workers around the world were in favor of *IMO*, there was a small opposition, mostly consisting of Dutch amateurs (DMS). Despite the wish of a large majority of the participants from abroad, the *IMO* debate was reduced to the scale of a workshop among several others. People who traveled big distances to decide on *IMO* matters saw their time spoiled at the workshop by a few Dutch people whose only aim was preventing any concrete decision. These people rarely participate in international events, and were not present at the 1989 *IMW* in Hungary. People came to some agreement during the informal talks after the unfortunate workshop. Consultations were continued by correspondence which led to a definite status by May 1, 1988.

Despite only a very few people opposed against *IMO*, the overall majority of meteor observers joined as founding members or contributed as observers. The 97 founding members live in 21 countries on 4 continents. All decisions were made by written vote through the *IMO* documents. The last such document contained the final version of the *IMO* constitution.

The author of the *IMO* constitution, Marc Gyssens, commented his work at the Founding Assembly. Some typical characteristics of the *IMO* constitutions are:

- The legal status of *IMO* is identical to that of the *International Astronomical Union* which has been founded according to the same Belgian law. The advantage of this law is that it provides corporate status for *IMO* as an *international* society rather than a national one. While this status is recognized by most countries in the world, Belgium is the only country that provides such legal possibilities.
- Typical for *IMO* is that it is a society of physical persons and not a federation of existing associations or local groups. *IMO* encourages individual persons to join, regardless their affiliations with local groups.
- The objective of *IMO* is to collect, to store and to analyze observations, to communicate results to the meteor community, to standardize observing methods, to enable a world-wide analysis of data, and to establish contacts with professionals.
- The constitution is adapted to amateurs who have limited traveling possibilities. People everywhere in the world must be able to take part in all decisions; therefore all votes are organized by mail. Although part of the *IMO* members may meet and discuss proposals, the decisions become effective only after all voting members were consulted and had the possibility to cast a written vote. In this sense, *IMO* meetings (General Assembly, Council) are rather a forum for discussion.
- All members can contribute to the organization by making appropriate proposals.

Since the constitution passed a long way through different voting documents, the final version was signed by 73 of the 97 founding members. The remaining 24 people probably forgot to return the final version leaving very few who were probably no longer interested. The names of the 73 final founding members will be published under the constitution. The other 24 will remain "ordinary" voting members.

In the document containing the final version of the constitution, the founding members also confirmed the Council elections. Jürgen Rendtel was elected as the first President of the *IMO*, and the other Council members are: Peter Brown (Assistant Secretary North America), Malcolm Currie (Director Telescopic Commission), Marc Gyssens (Editor *WGN*), Robert Hawkes (Scientific Advisor), Detlef Koschny (Relations Professionals-Amateurs, Organizer next *IMW*), Masahiro Koseki (Assistant Treasurer Japan), Vasilii Martynenko (Cooperation of amateurs in the Soviet Union and *IMO*), Alastair McBeath (Vice-President), Duncan Ollson-Steel (Scientific Advisor), Paul Roggemans (Secretary General), Ann Schroyens (Treasurer), Christian Steyaert (Director Computer Commission), Gabor Süle (Cooperation Hungarian amateurs in *IMO*), Alexandra Terentjeva (Scientific Advisor for visual observations), Casper Ter Kuile (Cooperation with Dutch amateurs, computer work and photography), Glenn Ticket (Cooperation Belgian amateurs) and Jeff Wood (Coordination observing programs with Australian teams).

After reading the composition of the Council, it was Marc Gyssens' pleasure to dissolve the Provisional Administration since its task was finished, and to declare *IMO* officially founded, implying the organization was henceforth to be managed by the Council. Consequently, he handed over the chair of the meeting to Jürgen Rendtel, the newly elected President. On behalf of the new Council, Malcolm Currie thanked the Provisional Administration for their efforts.

The President then asked the Secretary General to present the financial report, because the treasurer could not participate at the *IMW*. A brief summary on the financial situation was given. Next, the President encouraged East European *IMO* members to get their *IMO* membership paid through exchange of materials of interest to somebody in the West: journals, books, stamps, photos, coins, etc. People of the West who want to get a correspondent in the east to exchange something with should contact the Secretary General. Likewise, people from the East wanting to join *IMO* should sent their request to the Secretary General who will negotiate to find a sponsoring correspondent.

Then, the Commission directors were asked to present their programs. The audience got reviews by Malcolm Currie on telescopic work, by André Knöfel on Fireball data, by Jeroen Van Wassenhove on radio observing programs, by Ralf Koschack on visual work and by Christian Steyaert on the work of the Computer Commission. Detailed descriptions will be published later by the commission directors themselves.

With 17 Council members, one may wonder what these Council members do in *IMO*. Inactive Council members are of no use and therefore every Council member defined his/her function. These descriptions will be communicated to all *IMO* members in a forthcoming *IMO* document.

A number of associate members joined *IMO* since January 1, 1989. According to the constitution, associate members become voting members after acceptance by the first General Assembly following their entrance. This time, 26 new voting members were accepted. There are now 123 voting members. All associate members who joined or will join the organization between July 1, 1989 and May 31, 1990 will become voting member at the 1990 *IMW*, unless the General Assembly would object. In order to become an associate member, one must have a 1990 subscription to *WGN*, *and* return a signed membership application form, to be obtained from the Secretary General.

The General Assembly also accepted to submit for ballot the proposal to nominate *Bertil Lindblad* as honorary member. Dr. Lindblad has been working now for about 40 years on meteor astronomy and published numerous papers. He has often involved amateurs in his observing programs at Lund. He came to an *IMW* twice and makes a lot of efforts to improve the contacts between amateurs and professionals. Without his help and support, the relationship between amateurs and professionals would never have been what it is now. To express the gratitude of amateurs, *IMO* wants to offer honorary membership to Dr. Bertil Lindblad.

Before closing the meeting, the participants were given the opportunity to bring to the flour whatever they wished to discuss. Detlef Koschny came up with the idea of a meteorite commission to be established in *IMO*. Axel Haas works on this topic. Dr. Andreev of Tomsk State University (USSR) asked for the support of *IMO* to set up an international investigation project for the Tunguska event of 1908. He proposed to send official letters on behalf of *IMO* to the *UNESCO* and to officials in the Soviet Union. The President agreed on this proposal and will undertake the required steps.

Since there were no more items proposed to be discussed, the President thanked all the participants for coming and closed the Founding Assembly of *IMO*.

4. Back to the IMW

The evening was reserved for two workshops. The first workshop was led by Malcolm Currie who discussed the program of the *IMO* Telescopic Commission. The discussion points were prepared in a paper distributed at the *IMW*. After its conclusion, the workshop on visual work took place, following a detailed program for the discussion. The director, Ralf Koschack, stressed the need for a very strict observing procedure. One handicap in the visual work of *IMO* is that not all *IMO* observers use the same radiant information when they separate shower meteors from sporadics. This means that the sporadic rates are not comparable and thus cannot serve for calibration. A full report on these workshops will appear in the proceedings. It was well past midnight before everyone went to bed.

The last day of the weekend, Sunday October 8, started a bit chaotic. Several people were tired from the late Saturday evening program. The previous days, the lecture program had been followed very strictly, so the last day the program had to be adapted quickly according to the speakers that were available. After the last few lectures were presented, the *IMO* President closed the meeting thanking the Hungarian organizing committee for the accommodation they provided and their hospitality.

The first *IMW* in Eastern Europe was of great value for the cooperation between East and West European meteor workers. Although all European people share the same cultural and historic values, it has been difficult to work together for a long time. Years ago, until 1985, we faced the disappointments that *IMW* invitations did not get East European guests across the border. Artificial separation cannot last for ever and in 1988 it was decided to have the next *IMW* in Hungary. This weekend was a historic one; *IMO* had its Founding Assembly in a country where history books just started a new chapter!

5. The next IMW

The classical question at the end of each *IMW* is where to hold the next one! As mentioned earlier, it was proposed to shorten the time lapse between *IMW*s. It should be every year instead of every one and a half years. The participants voted on this question and a majority was in favor of annual meetings.

Meanwhile, we already have some news about the next weekend:

- *Period:* from Thursday evening, September 6, 1990 until Sunday noon, September 9.
- *Place:* Bruder-Klaus-Heim, D-8901 Violau (near Augsburg), in West Germany.
- *Program:* introduction of observing groups (Thursday evening), lectures on meteors and related fields, poster presentations, excursion to the Augsburg Planetarium (optional), 2nd General Assembly of *IMO*.
- *Accommodation:* in 4-bed rooms.
- *Approximate price for accommodation and full board:* 140,- DEM.
- *Official language:* English.
- *Correspondence address:* Detlef Koschny, Ostpreussenstraße 51, D-8000 München 81, FRG, tel. (+49) (0)89-93 33 12.

Program of the Visual Commission of IMO

Ralf Koschack

Minor bodies play an important role in the insight into processes of the formation of the solar system. The interest in reliable data on meteor showers increases because of the increasing knowledge on their parent bodies. Only few professional astronomers are working in the field of meteor observation. Radar programs carried out by professionals do not work continuously. Therefore amateurs can make a valuable contribution to meteor science. Visual observations do not require expansive equipment. Experience and perseverance of the observer only are decisive for success.

Aims of the visual commission are:

- coordination of visual observations all over the world;
- standardization of observing and analyzing techniques;
- utilization of observational data as closed material; and
- cooperation with professional meteor astronomers and other commissions of *IMO*.

1. Concrete targets

1.1. *Increase of reliability of visual observations.*

Only observations carried out
- under favorable circumstances,
- with defined aim, and
- by means of a useful observing technique

are of scientific value. For analyses, observations fulfilling pre-defined criteria are used (see "special instructions").

1.2. *Continuation of monitoring major showers and comparison with previous years.*

Targets are profiles of ZHR and population index.

1.3 *Systematic observation of minor showers.*

Targets are
- ZHR profile,
- calculation of population index,
- check of radiant position, and
- search for historical notices.

1.4. *Search for activity of theoretical radiants of Earth crossing asteroids and comets.*

1.5. *Elaboration of procedures for determination of spatial number densities, mass distributions, and flux densities from visual observations based on IMO standards.*

1.6. *Systematic distribution of observations throughout the whole year.*

There is a lack of winter and spring observations now. Regular observations are also important for training of the observers and to guarantee the reliability of their observations.

1.7 *The "Observers' Notes" in WGN highlight the showers to be observed preferably.*

2. Special instructions for observation and analysis

2.1. *General instructions.*

- All observations have to be based on the *IMO* standard presented in the "Visual Handbook".
- Analysis are carried out by means of the *VMDB*.
- Observing conditions should be as follows:
  - limiting magnitude better than 5.5;
  - cloudiness less than 10% during the whole observing interval; and
  - radiant altitude higher than 20° during the entire observing interval.
- An observation should be continued for at least 1.5 hours. Observations with $T_{\text{eff}} \geq 3$ have to be divided into intervals of 1.5 to 2.5 hours each. For choosing the interval limits, the observing conditions should be considered, e.g. the Perseid radiant reaches 20° altitude at 21^{h} UT and therefore the preceding intervals are not valuable for Perseid analysis.
- The total correction factor for a shower under study should not be greater than 2.
- The center of the field of view has to be reported for the middle of every interval (in right ascension and declination) with an accuracy of 10°.
- The radiant position and size are used for shower association which has to be reported.
- One must distinguish between
  - shower was analyzed, but no meteors were seen ($N = 0$); and
  - shower was not analyzed ($N = /$).

- The observing technique has to be reported:
  - all meteors plotted: P;
  - all meteors counted only: C;
  - all possible members of stated showers plotted, others counted: C/P;
  - coordinates of meteors estimated directly: R.

2.2 *Observations of major showers (present ZHR larger than 10).*

- All meteors should be counted only.
- Around the time of maximum, observations should be divided into 1^h intervals.
- In order to estimate activity around the time of maximum, observations should also be carried out if observing conditions are not as favorable as requested in 2.1.

2.3 *Observations of minor showers (present ZHR smaller than 10).*

- A reduced working list including only showers with significant activity and certain radiant position will be published and brought up to date from time to time.
- Special minor showers are highlighted in *WGN*'s "Observers' Notes".
- The center of the observing field should be located not more than 40° away from the radiant studied. If there are more radiants within a small area one should observe in a field nearer to the radiants.
- If no more than 20 meteors per hour are visible, it is recommended to plot all meteors or determine their coordinates, otherwise all possible members of the shower studied should be plotted.
- For plottings, the gnomonic *Atlas Brno* is recommended (suitable scale).
- Shower association should be carried out by means of *direction of path*, *angular velocity*, and *apparent trail length* at the desk after the observation.
- An analysis of the shower (activity profile, population index) is possible if the ZHR is at least 2 or 3.
- Radiants at more than 40° from the field's center should not be analyzed ($N = /$) in the report form).

2.4 *Search for activity of theoretical radiants of Earth crossing asteroids and comets.*

- Special theoretical radiants are highlighted in *WGN*'s "Observers' Notes".
- The distances between calculated radiant and the center of observing field should not exceed 20°.
- All meteors should be plotted, at least all meteors possibly radiating from an area of about 20° around the calculated radiant position. The coordinates (begin and end) of these meteors should be reported.
- Radiant analysis is carried out by means of all observations (telescopic, photographic, video and visual).
- Determinated radiant positions will be published.
- Shower associations can be carried out by the observers using the position found (for activity determination).

2.5 *Control of the quality of observations.*

An *IMO* Council member commissioned by the Council and the Director of the Visual Commission should be permitted to check the original data by a random test of original notes from several observers. Notes will be checked by both independently. This will also help unexperienced observers who do not observe in a group with experienced observers to know their possible errors and to get advice to improve their observations. Observers are not obliged to accept this check.

Status of the Radio Meteor Data Base

Jeroen Van Wassenhove

The *Radio Meteor Data Base (RMDB)* is available for 200,- BEF on $5\frac{1}{4}$" diskette (MS-DOS format). Due to the data structure, the *RMDB* still uses two different software packages: dBASE III Plus[1] and Lotus 1-2-3[2]. The *RMDB* consists of the following files:

Filename	Size	Description
RMDB1.WKI	64710	Denmark 1986
RMDB2.WKI	61959	Denmark 1987
RMDB3.WKI	4299	Canada 1987
RMDB4.DBF	1063	Hungary 1987
RMDB5.DBF	9600	Belgium 1987
RMDB6.WKI	57567	Denmark 1988, part 1
RMDB7.WKI	33340	Denmark 1988, part 2
RMDB8.DBF	66048	Belgium, Hungary, West-Germany 1988
RMDBEQ.DBF	2296	List of used equipment
OBSERVER.DBF	8192	Observers information
VMDBSITE.DBF	17914	List of Sites
READ.ME	2406	General information

For the observers and site data, the same format is used as in the *Visual Meteor Data Base (VMDB)*. This makes the *RMDB* compatible with the *VMDB*. We will keep you informed about new developments.

IMO Computer Commission Questionnaire: Results

Christian Steyaert

Twenty eight *IMO* members from ten countries (Belgium, Bulgaria, Czechoslovakia, Federal and Democratic Republics of Germany, Hungary, the Netherlands, Norway, the UK and the USA) returned timely the questionnaire which appeared in the October issue of *WGN*: a representative and motivated public![3] A vast majority (19) has an *IBM PC (compatible)* with *at least 512 K* with a ***hard disk*** and *graphics* (Hercules (4), EGA (8), others (2)). The other machines in use are: Atari ST (4), Commodore C-64 (4), Mac II (3), others (5). Some people can use VAX or other workstations, mainly at their institute or at work. Diskette format is still mainly $5\frac{1}{4}$" (16), but also $3\frac{1}{2}$" (9). Most people have a matrix printer (23), some can use a laserprinter. A mouse (11) as an input device is fairly common (some computers rely completely on it). Only four persons have a modem, and two own a scanner.

It should be noted that the situation about the hardware is very different from country to country. In the East-Block countries for instance, there would be an interest in modems, but the restrictions on the use are enormous.

About programming languages, *Pascal* (17) and *BASIC* (16) are the clear winners. On some of the earlier machines, only an elementary BASIC is available, whilest the more recent releases offer much the same possibilities of a structured language like Pascal. Amongst the mini-users,

[1] a trademark of Ashton-Tate.
[2] a trademark of Lotus Development Corporation.
[3] The numbers between brackets are the numbers of answers.

Fortran (6) is much used, while four people indicate they also use C. Three *IMO* members use an even higher level language.

For file management, *dBASE III*/Foxbase (13) is well established. The Lotus spreadsheet (6) is used for graphing and some other analysis. Although not asked explicitly, several persons indicated their favorable word processor: WordPerfect (3), TEX (2) and MS-Word. A couple of other packages are used for statistical analysis or symbolic analysis.

More important is which direction the Computer Commission should take, realizing that not everything can be done, and priorities and choices will have to be made. The votes for the priorities are: (the average is obtained by assigning −1 to Low, 0 to Medium and +1 to High).

standardizing file layouts:	L: 2	M: 9	H: 15	Avg.: +0.5
ready-to-use programs:	L: 3	M: 8	H: 16	Avg.: +0.5
source programs and toolkits:	L: 3	M: 12	H: 12	Avg.: +0.3
mathematical methods:	L: 1	M: 8	H: 17	Avg.: +0.6
data communication (modem):	L: 4	M: 15	H: 5	Avg.: +0.0
advising soft- and hardware:	L: 11	M: 9	H: 4	Avg.: −0.3

Highest priority is given to mathematical methods in meteor-astronomy. This critical attitude towards observational results and how to interpret these proves that people with a solid scientific background get involved in *IMO* and the fuzzy field of meteors. File layout standardization is a must for distributed entry and analysis of results. File layouts and masterfiles should be available to all interested parties for an efficient cooperation. There is a vast amount of ready-to-use (astronomical) programs available—both commercially and in free domain. *IMO* can be seen as a kind of quality control before passing on existing programs, or, of course, can develop itself specific programs. Most people like to program themselves too, hence want also to have the source programs. Several software modules are standard and can be re-used as a toolkit. Data communication is not that widespread yet—but is certainly a field on the move-up. Finally, most people believe that *IMO* cannot play a big role in soft- or hardware selection, whose availability is dictated by the market and furthermore hard to follow. Computer magazines and local contacts fulfil already this role.

Based on all this and individual requests, the following action plan, effective immediately, is developed:

- the photographic astrometric method used for the *PMDB* so far will be translated in English, and the corresponding program and star catalogue will be made available as an add-on diskette to the publication. (Christian Steyaert (B) and Reiner Arlt (DDR), β-users Trond Erik Hillestad (DK) and Tamas Zalazak (H));
- the forward scatter ephemeris program for radio observers will be expanded (Christian Steyaert, Jeroen Van Wassenhove, Dirk Artoos (B));
- a toolbox with the classical astronomical calculations (date, solar longitude, planetary orbits, ...) will be built gradually; and
- an effort will be made to attract more co-workers to make existing programs available in other languages and for other hardware.

The Floppy Almanac

Christian Steyaert

Although most of us can perform astronomical calculations on a calculator or a personal computer, there is a demand for ready to use and proven programs. In that respect, the computerized version of the Nautical Almanac, the *Floppy Almanac*, is a great initiative and is also of use for meteor workers.

The Floppy Almanac is available on $5\frac{1}{4}$" or $3\frac{1}{2}$" diskette for MS-DOS, but also on $5\frac{1}{4}$" 400 K RX50 disk for VAX and MicroVAX and on 9-track 1600 bpi tape VM/CMS format for IBM370, 43xx, 30xx. The PC version will recognize automatically a math coprocessor (8087 or 80287).

The system is menu driven. The observer's position and some other parameters are stored in an initial values file which can be changed any time. One can calculate:

- sidereal time,
- physical ephemeris of the planets,
- positions of planets, stars,
- navigational information,
- rise and set times of stars, planets, and
- daily configuration.

The latter option is interesting in planning meteor observing campaigns, as it gives the rise and set of the Sun and Moon. Also important is that the output can be redirected to a file, hence allowing further processing or graphical presentation by other software. The Floppy Almanac has a standard 200-star catalogue. It can easily be replaced by another one: for our use e.g., by a radiant catalogue.

The current version of the Floppy Almanac is valid for just one year, with some overlap in the previous and next year. Currently, the USNO is working on the Interactive Computer Ephemeris (ICE), which is valid from 1801 to 2049! The Floppy Almanac can be obtained at:

Nautical Almanac Office, Code FA, U.S. Naval Observatory, Washington, DC 20392, USA.

The Floppy Almanac costs 20 USD for the first disk, and 10 USD for each additional disk (payment by check only). The Floppy Almanac is not public domain nor shareware.

New Earth-Grazing Asteroids

Chris Steyaert

Information is provided on recently discovered asteroids and comets whose closest distance to the Earth's orbit is less than 0.1 AU and on the meteor activity they might produce. The present article covers asteroids 1989 UP, 1989 UQ, 1989 UR and 1989 VB.

In the future, we will regularly provide information about recently discovered Earth-Grazing Asteroids or comets, whose shortest distance to the Earth's orbit is less than 0.1 AU. Possible shower activity can be associated with these objects. Activity can be very sharp or non-existent.

1989 UP was discovered by D.L. Rabinowitz and J.V. Scotti, University of Arizona. Orbital elements from 12 observations, Oct 27– Nov 2 were given in IAU Circular 4894, 1989 November 3, by Daniel W.E. Green (Eq. 1950.0):

$T = 1989$ Nov 26.210 ET	$\omega = 17.^\circ150$
$e = 0.47553$	$\Omega = 52.^\circ852$
$q = 0.98235$ AU	$i = 3.^\circ870$
$a = 1.87303$ AU	$P = 2.48$ years

We found a closest approach to the Earth's orbit on Nov 18.9 at ($\lambda_\odot = 235.^\circ9$) at a distance of 0.0052 AU, i.e. only 770 000 km! Possible associated meteors would have the low speed $V_\infty = 13.1$ km/s, and a radiant with $\alpha = 358°$ and $\delta = -23°$.

1989 UQ was discovered by C. Pollas, Observatoire de la Côte d'Azur. Orbital elements by B.G. Marsden, Center for Astrophysics are (IAU Circular 4897, 1989 November 5, Eq. 1950.0):

$T = 1990$ Mar 8.656 ET	$\omega = 14^\circ\!.891$
$e = 0.26643$	$\Omega = 178^\circ\!.086$
$q = 0.67134$ AU	$i = 1^\circ\!.288$
$a = 0.91518$ AU	$P = 0.88$ years

In this case, there are two close approaches to the Earth's orbit. One is on Dec 4.7 ($\lambda_\odot = 251^\circ\!.9$) and the other on Aug 13.6 ($\lambda_\odot = 140^\circ\!.3$). The possible meteor shower characteristics are respectively:

$V_\infty = 13.5$ km/s	$\alpha = 90^\circ$	$\delta = +24^\circ$	$d = 0.021$ AU
$V_\infty = 13.5$ km/s	$\alpha = 125^\circ$	$\delta = +23^\circ$	$d = 0.014$ AU

J. Mueller and D. Mendenhall reported their discovery of a fast-moving asteroidal object, **1989 UR**. Preliminary orbital elements by B.G. Marsden are (IAU Circular 4891, 1989 November 2, Eq. 1950.0):

$T = 1990$ Feb 11.702 ET	$\omega = 289^\circ\!.905$
$e = 0.36509$	$\Omega = 233^\circ\!.769$
$q = 0.68748$ AU	$i = 10^\circ\!.652$
$a = 1.08281$ AU	$P = 1.13$ years

There are again two approaches to the Earth's orbit, respectively on November 26.6 ($\lambda_\odot = 243^\circ\!.7$) and June 11.1 ($\lambda_\odot = 79^\circ\!.6$):

$V_\infty = 16.5$ km/s	$\alpha = 68^\circ$	$\delta = +46^\circ$	$d = 0.035$ AU
$V_\infty = 16.4$ km/s	$\alpha = 80^\circ$	$\delta = -06^\circ$	$d = 0.090$ AU

Finally, **1989 VB** was discovered independently by Q.A. Parker and by C.S. Shoemaker, E.M. Shoemaker and D. Levy. Orbital elements by B.G. Marsden, Center for Astrophysics, from 12 observations Nov 1–5 (IAU Circular 4901, 1989 November 7):

$T = 1989$ Oct 8.226 ET	$\omega = 329^\circ\!.526$
$e = 0.45660$	$\Omega = 38^\circ\!.390$
$q = 1.00519$ AU	$i = 2^\circ\!.118$
$a = 1.84983$ AU	$P = 2.52$ years

The closest approach to the Earth's orbit is on October 9.9 ($\lambda = 196^\circ\!.0$) with $d = 0.017$ AU, $V_\infty = 12.9$ km/s, $\alpha = 268^\circ$ and $\delta = -34^\circ$.

Visual Observers' Notes : January and February 1990

Jeff Wood

Although early January begins with the major shower, the Quadrantids, this period has been characterized as one with low rates and so must therefore hold little interest to the meteor observer. This attitude however, is based on a misconception. Even though rates may be low, there is still much to see as southern hemisphere observers and those in the northern hemisphere who have braved the winter weather, have discovered. Table 1 below lists ten of the more important showers that occur during January and February.

Table 1 – A list of some of the meteor showers to be seen in January–February 1990.

Shower	α	δ	Period	Max
Quadrantids	230°	+49°	Dec 31–Jan 05	Jan 03
γ-Velids	125°	−47°	Dec 29–Jan 15	Jan 06–09
α-Crucids	188°	−63°	Jan 06–28	Several
δ-Cancrids	126°	+20°	Jan 13–21	Jan 16
α-Carinids	95°	−54°	Jan 24–Feb 09	Feb 01
α-Centaurids	210°	−59°	Jan 28–Feb 23	Feb 08
o-Centaurids	177°	−56°	Jan 31–Feb 19	Feb 12
δ-Leonids	159°	+19°	Feb 05–Mar 19	Feb 26
θ-Centaurids	210°	−40°	Jan 23–Mar 12	Several
η-Virginids	186°	−01°	Feb 03–Apr 15	Several

Table 2 shows moonlight and observing conditions.

Table 2 – Moonlight and observing conditions in January–February 1990.

Date	k	Date	k
Friday December 29	0.01+	Friday February 02	0.41+
Friday January 05	0.56+	Friday February 09	0.99+
Friday January 12	0.99−	Friday February 16	0.67−
Friday January 19	0.49−	Friday February 23	0.07−
Friday January 26	0.01−	Friday March 02	0.27+

New Moon:	December 28, January 26, Februay 25
First Quarter:	January 4, Febuary 2, March 4
Full Moon:	January 11, Februay 9, March 11
Last Quarter:	December 19, January 18, February 17

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.

1. Quadrantids

The Quadrantids are only observable from the northern hemisphere. There, during the last few hours before sunrise on the morning of Jan 3–4, rates more than 30 meteors per hour can be recorded under good sky conditions. When we consider that the radiant altitude is still fairly low at this time, the corrected rates give a ZHR comparable to that of the η-Aquarids, Perseids and Geminids thus making the Quadrantids a truly major shower.

The Quadrantid radiant is situated in the northeast corner of the constellation of Bootes which used to be known as the constellation Quadrans Muralis from which the shower's name derives. Quadrantid meteors are very brilliant and many produce trains. Frequent poor weather has meant that data on this shower is comparatively scarce. Thus with favorable Moon conditions, observers are encouraged to brave the cold of winter and observe this shower in 1990.

2. Minor showers

The γ-*Velids* are a southern hemisphere stream observable through the first half of January that reaches a broad maximum of 5 to 9 meteors per hour from January 6 to 9. The γ-Velids are medium speed meteors and are mostly blue, yellow and white in color. Few γ-Velid meteors leave a train but those that do leave one that is often persistent. The γ-Velids will experience considerable interference from the Moon in 1990.

The α-*Crucids* were first observed in the 1920's and 1930's by R. McIntosh and C. Hoffmeister respectively. Despite being recorded so long ago, very little systematic study was done on it until the past decade. Studies indicate that the stream is active from January 6 to 28 and has several maxima that occur between January 12 and 20. Rates are generally of the order of 2 to 5 meteors per hour, and can vary from year to year. In 1990 much of the α-Crucids period of activity will be affected by the Moon.

The δ-*Cancrids* produce only one or two meteors per hour at maximum and will disappoint viewers in 1990 by the heavy interference with the Moon.

The α-*Carinids* are a virtually unknown southern hemisphere stream. They are active from January 24 to February 9 reaching a sharp maximum of between 5 and 10 meteors per hour on February 1. Observations to date seem to indicate that this stream is quite variable in activity and so more research is urgently needed into this matter. 1990 promises to be a good time to view the α-Carinids with very little interference from the Moon. The α-Carinid radiant is situated near Canopus and is best observed in early evening hours. α-Carinid meteors are generally slow in speed and have a yellow/orange hue.

With the Full Moon on February 10, both the α-*Centaurids* and the *o-Centaurids* are heavily affected. However, since they both produce many bright meteors and also that there is a possibility of enhanced display, these streams should be monitored in 1990. The α- and *o*-Centaurids both produce fast bright yellow meteors. Many of them leave a train.

The δ-*Leonids* are a minor shower that occurs during February and March each year. Although Cook lists the δ-Leonids to reach maximum on February 26, it appears that it more likely should be February 22. The δ-Leonids are a fairly weak stream with rates generally about 1 to 2 meteors per hour at best. They are characterized by their slow speeds. With favorable Moon conditions, the δ-Leonids should be targeted by observers in 1990.

The θ-*Centaurids* are a southern hemisphere stream very similar to the Taurids in terms of its duration and activity. However, this is where the similarity ends with the θ-Centaurids possessing a much faster speed and having only one condensed center of radiation. The θ-Centaurids can be seen from from January 23 to March 12 and appear to have several maxima in early, mid and late February. Maximum rates appear to be in the range of 4 to 7 meteors per hour. An unusual characteristic of the θ-Centaurids are the number of meteors of magnitude -4 or brighter and the persistent trains they leave. One θ-Centaurid meteor seen in 1981 was magnitude -16 at its brightest and left a naked-eye train that lasted for some 32 minutes.

The η-*Virginids* are one of the major components of the Virginid complex of radiants to be seen from February to April each year. The η-Virginids appear to have several maxima, one of which occurs towards the end of February. η-Virginid activity like the other components of the Virginid complex is very low usually being 1 meteor or less per hour. On very rare occasions, it has been known to reach 3 meteors per hour, but this is the best that can be expected. Because of their long period of activity, the observer is urged to watch at least some of this time.

Results about Enhanced Radio Meteor Activity

Dirk Artoos

In earlier issues, the present author drew the attention of the international meteor community to possible enhanced (radio) meteor activity on certain dates. Here, the author discusses some preliminary results.

In connection with the call regarding P/Brorsen-Metcalf [1] I received a visual report of the theoretical maximum from Richard Taibi (Maryland, USA). Unfortunately, he saw no enhanced activity. The meteor section of the Public Observatory Urania (Hove, Belgium) made radio observations. They too observed nothing special, but were plagued by Sporadic E. I myself observed between September 4 and 12, always from 23^h45^m to 0^h20^m UT, and on the day of the theoretical maximum (September 8) had to deal with Sporadic E as well.

Table 1 – Numbers of reflections obtained by Dirk Artoos from 23^h45^m to 0^h20^m UT.

Date	*N*	Date	*N*	Date	*N*
Sep 04–05	57	Sep 07–08	Spor E	Sep 10–11	44
05–06	52	08–09	Spor E	11–12	42
06–07	5	09–10	70		

The night of September 9–10, though, there was a higher number of reflections, but I refuse to draw any definitive conclusions.

Here follow my observations in connection with a suspected radiant near Orion-Gemini [2]. It seems a success; take a look at the results:

Table 2 – Numbers of reflections obtained by Dirk Artoos from 8^h30^m to 9^h10^m UT.

Date	*N*	Date	*N*	Date	*N*
Sep 14	64	Sep 17	65	Sep 19	63
15	80	18	61	20	43
16	96				

I always observed from 8^h30^m to 9^h20^m UT. Please note that the increase in number of reflections on September 16 may not be confirmed by visual observers because most of them were very short (and therefore very weak) meteors. I await further news from visual as well as telescopic observers.

A third call [3] related to a possible Sextantid shower on September 27. I can only say that the very positive results gathered on September 28, 1988 [4] were confirmed this year around September 28.

Table 3 – Numbers of reflections obtained by Dirk Artoos during half an hour of observing.

Date	*N*	Date	*N*	Date	*N*
Sep 22	67	Sep 26	62	Sep 30	84
23	65	27	99	Oct 01	74
24	70	28	85	02	62
25	68	29	94		

With a mean background activity of 67 reflections per half hour, one can clearly notice a sudden increase on September 27, continuing this trend up to September 30. The question which does arise is whether the first peak belongs to the δ-Aurigid stream, producing a secondary peak on September 30, or whether they are really caused by the Sextantids.

References

[1] D. Artoos, "September 8 and P/Brorsen-Metcalf", *WGN* 17:4, August 1989, p. 120.

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

[3] D. Artoos, "Enhanced Activity around September 27–30?", *WGN* 17:4, August 1989, p. 121.

[4] D. Artoos, "The 1988 Sextantids", *WGN* 17:2, April 1989, pp. 49–50.

Unusual Meteor Activity in January 1989

Jeroen Van Wassenhove

Enhanced meteor activity around January 21–22 was reported by several observers.

1. Observations

Several radio observers listened during the second part of January 1989. Two of them, Dirk Artoos (B) and Gotfred M. Kristensen (DK) reported an increase of meteor activity in the morning of January 22. The observations of both persons are shown below. Dirk Artoos observed on 66.45 MHz at an azimuth of 275° (South=0°) and an elevation of 40°; Gotfred Kristensen listened on 100.50 MHz at an azimuth of 0° and an elevation of 35°.

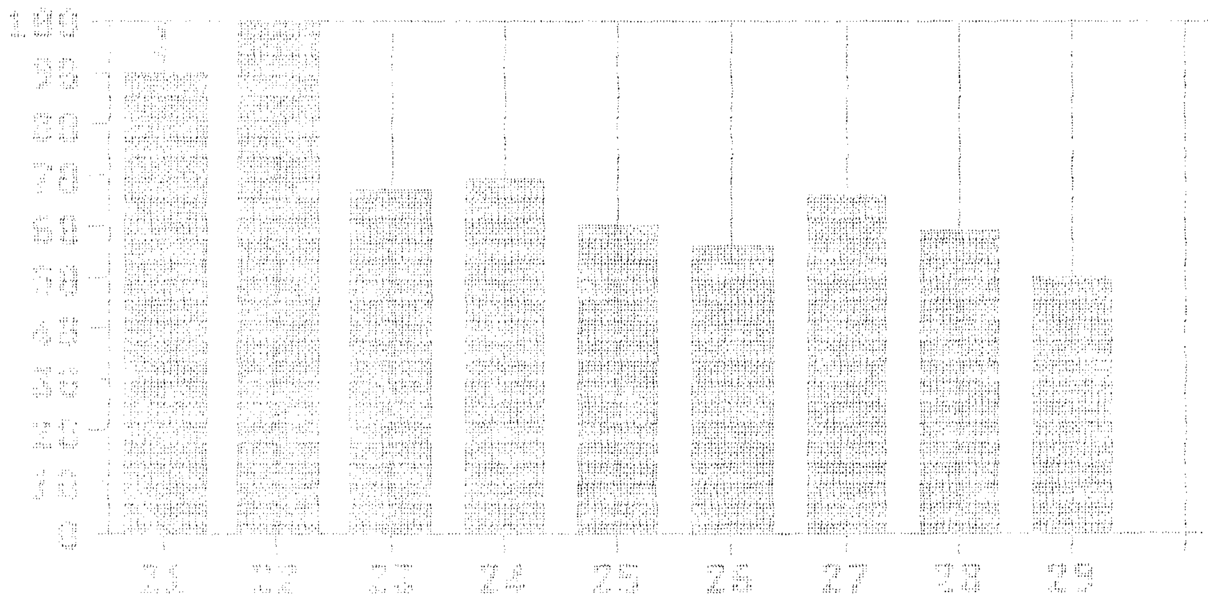

Figure 1 – Radio observations by Dirk Artoos in January 1989 between 3^h45^m and 4^h15^m UT.

Table 1 – Radio observations of Gotfred Møbjerg Kristensen (GMK) and Knud Bach Kristenson (KBK) in January 1989.

Obs	Period (UT)	18	19	20	21	22	23	24	25	26	27	Average
GMK	6^h00^m–7^h00^m	9	15			50	9	12	16	6	16	16.6 ± 13.9
KBK	3^h00^m–4^h00^m	12	39	31	22	22	7	13				20.9 ± 11.3
KBK	4^h00^m–5^h00^m	16	21	25	16	22	5	7				16.0 ± 7.6
KBK	5^h00^m–6^h00^m	14	14	20	17	12	11	9				13.8 ± 3.8
KBK	6^h00^m–7^h00^m	9	7	17	21	16	2	10				11.7 ± 6.5

Knud Bach Kristenson (DK) also listened in the second half of January on 144.456 MHz at an azimuth of 191° and an elevation of 18°. His observations are also presented above.

2. Discussion

As one can notice, two observers (Dirk Artoos and Gotfred Kristensen) have an increase of meteor activity in the morning of January 22. One observer, Knud Bach Kristenson, did not report anything significant. Why did he not observe this increased activity while the others did? The three observers all used a different frequency. As each frequency has its own FM station(s), each antenna is pointed in another direction. This implies that the observing circumstances (position "supposed radiant"–antenna direction) were different. So it is most likely that Knud Bach Kristenson could not observe this increase due to bad observing circumstances.

Now the final question rises. What was the cause of this sudden increase of meteor activity? Some literature [1,2,3] was consulted, but no association with a known meteor shower could be found.

3. Conclusion

The increased meteor activity in the morning of January 22, 1989 cannot be associated with a known meteor shower yet. Further investigations and future observations will provide an answer, whether this increase is caused by an unknown meteor shower or by fluctuation of the sporadic background.

References

[1] A.F. Cook, "A working list of meteor streams", Smithsonian Astrophysical Observatory, Cambridge, Mass.

[2] McKinley, "Meteor science and engineering".

[3] A.C.B. Lovell, "Meteor astronomy".

Call for Action: January 1990

Dirk Artoos

The author discusses the possibility for enhanced meteor activity around January 21–22.

I would like to call your attention to a possible increase of activity around January 21 and 22, 1990. On the same dates in 1989 there existed an unexplainably high activity at 3^h UT ($\lambda_\odot = 301\overset{\circ}{.}53$) [1]. Considering the suspected radiants[1]

- α-Leonids $\alpha = 156°$ $\delta = +09°$
- Canes Venaticids $\alpha = 111°$ $\delta = +10°$
- Association 60 (twin shower) $\alpha = 144°$ $\delta = +10°$

one would think it best to observe between 3^h and 4^h UT, yet considering the observed 1989 maximum (at September 22, 3^h UT or $\lambda_\odot = 301\overset{\circ}{.}53$), I would suggest 9^h20^m UT for 1990. The visual observer should pay special attention to Leo and Canes Venatici. In 1989, 95 very short reflections (very weak visual meteors) were observed. Perhaps the telescopic observers should carefully screen this region as well.

In conclusion, I would like to take the opportunity to stress that only consequent and regular observing leads to interesting results. Please do observe on a regular basis, not exclusively during periods of high and well-known activity; these periods remain important, but on the other hand loads of information get lost in the so-called silent periods. To me it would mean positive confirmation of my observations, where otherwise I would stand isolated and find it more and more difficult to defend my data scientifically. I wish to thank the observers who have supported me and sent me their findings (Richard Taibi, Urania meteor section). I do intend to continue in this way and will try to regularly activate observers so that progress can be made in a scientific and dynamic way.

[1] J. Van Wassenhove, "Unusual Meteor Activity in January 1989", *WGN* 17:6, December 1989, pp. 186–187.

[1] The third one is from P.B. Babadzhanov, Institute of Astrophysics, Dushanbe, USSR.

Satellite Re-Entries and Other Transient Optical Phenomena

Christopher E. Spratt

A short report of other transient phenomena of the atmosphere, which are sometimes mistaken for meteoritic fireballs, is presented.

High above our heads, in a very different type of orbit from the solar orbits of meteoroids, are thousands of satellites, parts of booster rockets, at least one astronaut's glove, and other assorted junk. Chances are that you will see one of these re-enter and burn up in the atmosphere. These are not so difficult to differentiate from a typical meteoritic fireball as they have a slower speed compared to a natural meteor, last a lot longer, and often can be seen to fluctuate in brightness during break-up. Also, unlike a fireball or meteor, they seem to last forever as they travel slowly across the sky. Some paths can exceed 90° and last up to 30 seconds [1]—far longer than the typical 3 to 7 seconds of a fireball.

Even though these are not true fireballs—fill out the *Fireball Report Form* anyway, noting your observation as a *suspected satellite re-entry*. There are those interested in obtaining satellite re-entry debris for study.

Occasionally there have been reports of other "balls of fire" which have been mistaken for meteoritic fireballs. Such a transient event is called *Kugelblitz* ("ball lightning"). This phenomenon was once discounted as a genuine electrical effect, but is now generally accepted as a real (albeit transient) physical event of the atmosphere [2]. The average life-time of this phenomenon has been reported to be about six seconds and the median size is about 0.35 m [3].

Not to be confused with Kugelblitz is a similar atmospheric phenomenon known as *St. Elmo's Fire* [2]—a glowing luminescence hovering above a metallic conductor. Usually it is observed on the masts and yardarms of vessels at sea. In configuration it usually occurs as a violet or faint blue colored, oval or ball-shaped glow, 0.1 to 0.4 m in diameter [2]. The difference between Kugelblitz and St. Elmo's Fire is that the latter usually remains near to a conductor of some sort.

Unlike a satellite re-entry or that of meteoritic fireball, the other two phenomena are also very localized. If only one or two observers, in very close proximity, report either Kugelblitz or St. Elmo's Fire, as a fireball, we should adopt either hypothesis as an explanation for that particular fireball phenomenon.

References

[1] D.H. Levy and S.J. Edberg, in *Observe Meteors*, Astronomical League, Washington DC, 1986, p. 25.

[2] P.A. Stahl, *J. Roy. Astron. Soc. Can.* 74, 1980, pp. 168–172.

[3] W.D. Rayle, *NASA Technical Note* TN-D-3188, 1986.

We are looking for meteor workers that have **slides** on their activities. It would be a nice thing if we would be able to compose a series of slides showing what meteor work is all about. Interested people who have appropriate material should contact *Paul Roggemans* (address on inside of back cover).

Also, people having made good meteor **photographs** can send them to *WGN*. If you are lucky, your photograph will be used for the front cover!

On the Pollution of Visual Meteor Stream Counts by the Sporadic Background

Marc Gyssens

The contribution of the sporadic background to visual meteor stream counts is calculated from a probabilistic viewpoint. It is found that the ZHR of a stream is augmented by about 0.5–1. As a consequence, minor showers with typical ZHRs not exceeding 3 cannot be studied by means of single station visual observations. The same conclusion holds for larger showers at the very beginning and the very end of there activity period.

1. Introduction

For over a century already, minor showers have been a controversial issue in meteor astronomy. In 1899, W.F. Denning [1] compiled a radiant catalogue containing over a thousand entries. Although it is generally accepted that most of his showers are probably spurious, and although more cautious authors, such as Cook [2] have compiled more reliable catalogues since then, many amateurs still use catalogues based on Denning's (e.g. [3]).

The catalogue of Denning and its offsprings have been based mainly on one station visual work. During an average night, about 20 of Denning's radiants are supposed to be active. Under these circumstances, almost every meteor seen lines up with at least one of these radiants, and many of them even with two or three! Obviously, there are limitations to what showers can still be detected and studied meaningfully by one station visual observations. It is the purpose of this article to calculate probabilisticly to what extent the sporadic background contributes to visual meteor stream counts.

2. Some notions of non-discrete probability theory

In this section, we review some basic notions of general non-discrete probability theory as we assume many readers are not familiar with this area. In order to be able to apply probability at all, we need to specify the "observation" or the "experiment" we wish to study. For the sake of having an example, suppose we want to measure the length of some object. Next, we have to specify the *sample space* $\mathcal{U}$, representing all possible results of our observation or experiment. In our example, we could use for U the set of all real numbers.

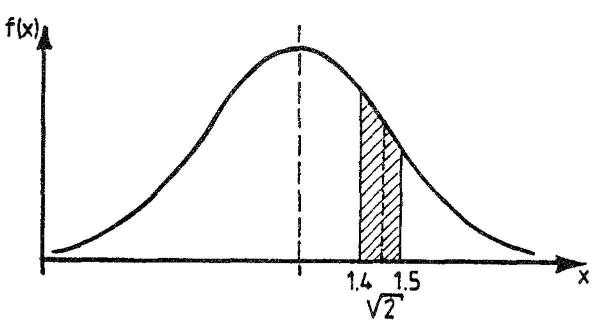

Figure 1 — Density function of a Gaussian or normal distribution

To each element P in $\mathcal{U}$, we then associate a *density* $f(P)$. In the case of a "fair" measurement, this *density function* usually is a Gaussian or normal curve (see Figure 1). The possible results, i.e. the elements of the sample space $\mathcal{U}$, do also represent the *simple or atomic events* of the observation or experiment. In our example, given a real number x, the corresponding simple event is: "the measurement equals x." In a non-discrete sample space, the probability for a simple event to occur is most often zero. Indeed, it is most unlikely that, for instance the result of a measurement, would *exactly* equal some preset real number (e.g. $\sqrt{2}$) in *all* its (infinite number of) decimals. We are rather interested in the probability for a *compound event* such as: "the measurement will return a value between 1.4 and 1.5.". To such a compound event, one can associate a *subset* V of the sample space $\mathcal{U}$. In the case of our example, this is the interval $V = [1.4; 1.5]$. To obtain the probability of a compound event, we need to calculate the integral $\int_V f dV$. In our example, the probability for the measurement to yield a value between 1.4 and 1.5 equals $\int_{1.4}^{1.5} f dV$. Since a probability of 1 is associated to a certain event, it follows that the density function f must satisfy the condition $\int_{\mathcal{U}} f dV = 1$. For instance, any

Gaussian function f satisfies $\int_{-\infty}^{+\infty} f(x)dx = 1$.

The intuitive meaning of the density function $f(P)$ is that the probability for the result to be *around* P, is proportional to $f(P)$[1] We invite the reader to convince himself of the truth of this conjecture by looking back to Figure 1.

Before ending this mathematical digression, we want to point out that choosing an appropriate sample space and a corresponding density function always yields a certain "idealization" of the experiment. In our earlier example, for instance, only reals with a fixed maximal number of decimal can occur as a result, due to the limited accuracy of the measuring equipment. Furthermore, a normal curve extends from $-\infty$ to $+\infty$, whereas obviously only nonnegative results can occur. However, the "errors" introduced by such "idealizations" do not outweigh the advantage of having a simple framework in which calculations are feasible.

3. A probabilistic model for meteor trail directions

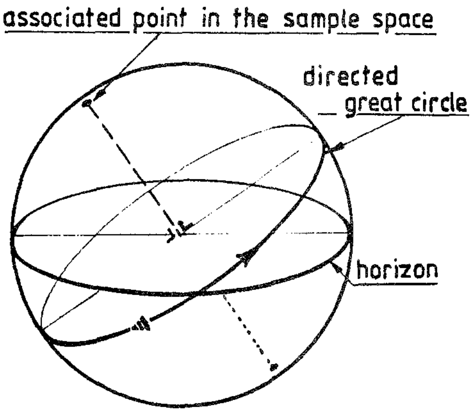

Figure 2 — The sample space

In this section, we are interested in the direction a sporadic meteor *trail* has in the sky, which is determined by the great circle along which the meteor moves and its sense, rather than the physical direction of the meteor *path* in space, which is determined by the radiant position.

We are now going to construct a probabilistic model for the following observation: *"give the direction (i.e. great circle and sense) in which the next sporadic meteor will move."* Quite conveniently, we choose as the sample space for this observation the celestial sphere, which we can, without loss of generality, assume to have unit radius. Thereto, we associate a point to each directed great circle on the celestial sphere, namely its "north" pole ("north" being defined as the direction from which the orientation of the great circle looks clockwise). See also Figure 2.

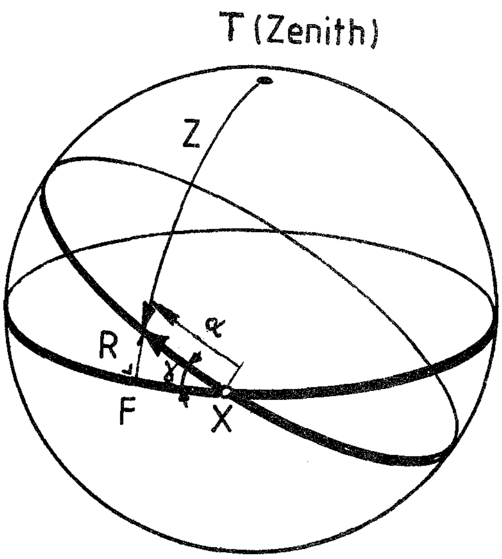

Figure 3 — The contribution to the sporadic background of the meteors moving along a directed great circle making an angle γ with the horizon.

In order to determine the density function, we assume that the *spatial distribution* of the directions of sporadic meteor paths is uniform. Neglecting atmospheric influences, we may thus say that the "frequency" of a point on the celestial sphere as a radiant position of a sporadic meteor *seen by the observer* is proportional to $\cos Z$, Z being the zenith distance of that point.

We are now going to compute the contribution to the sporadic background of all meteors moving in the sky along a directed great circle making an angle γ with the horizon. If a meteor moves along such a great circle, its radiant is of course also on that great circle. Therefore, assuming that from each radiant point meteors are likely to radiate away uniformly in all celestial directions, the contribution of the entire great circle to the sporadic background is proportional to the sum of the contributions of all the radiant points on it, which is thus proportional to $\int_0^{\pi} \cos Z d\alpha$, ex-

[1] Note that this somewhat vague statement can be made very precise. Such a formalization, however, goes well beyond the scope of this paper.

pressing all angles in rad (Figure 3). Now, in the rectangular spheric triangle FRX we have $\sin(\pi/2 - Z) = \sin\alpha \sin\gamma$, or, $\cos Z = \sin\alpha\sin\gamma$. Hence $\int_0^\pi \cos Z d\alpha \propto \sin\gamma$.

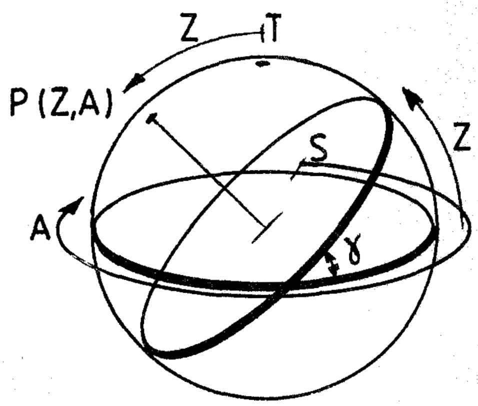

Figure 4 — The calculation of the density function.

Now consider a point P on the celestial sphere with zenith distance Z as a point of the sample space (Figure 4). Such a point represents a directed great circle making an angle $\gamma = Z$ with the horizon. Since the number of meteors moving along such a great circle is proportional to $\sin\gamma = \sin Z$, we have to associate to P a density $f(P) = C\sin Z$, with C a constant. C is determined by the condition that over the entire celestial sphere Σ,

$$\iint_\Sigma f dS = 1$$

or, using horizon coordinates Z (zenith distance) and A (azimuth):

$$1 = \int_{A=0}^{2\pi}\int_{Z=0}^{\pi} f(Z,A)\sin Z dZ dA = 2\pi C\int_0^\pi \sin^2 Z dZ = \pi^2 C$$

yielding $C = 1/\pi^2$. The desired density function is thus:

$$f(Z,A) = \frac{1}{\pi^2}\sin Z.$$

4. Pollution of stream counts by the sporadic background

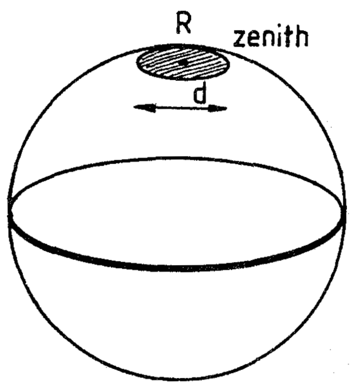

Figure 5 — A radiant in the zenith.

We will now calculate the contribution of the sporadic background to a meteor stream. For the time being, we assume the observer is watching a stream with radiant R *in his zenith*. We assume that the "effective" diameter of the radiant is d. By "effective diameter", we mean that the observer will classify a meteor as a stream member if its backward prolongation passes the radiant by a distance of at most d.

In order to estimate the probability that the backward prolongation of the meteor intersects the radiant area, we first calculate the probability that the great circle, along which the meteor moves, intersects the radiant area and divide the result by two. Indeed, for each meteor having its beginning and ending point outside the radiant area moving away from the radiant, another meteor can be associated moving towards the radiant, by simply reversing the order.

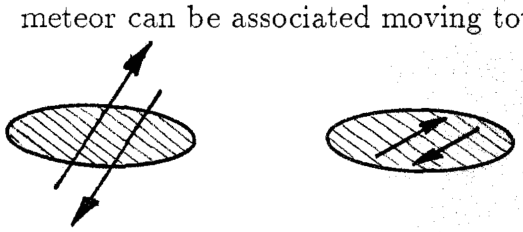

Figure 6 — Meteors intersecting the radiant area.

For d small, a vast majority of meteors moving along a great circle intersecting the radiant area, do not cross that area. Half of these meteors can be classified as belonging to the stream. A small number of meteors crossing the radiant area cannot be classified to the stream, no matter in which direction they move (Figure 6, left). For d not too small, their influence, however is somewhat compensated for by near-point meteors entirely within the radiant area (Figure 6, right). For these reasons, we may safely assume that our 50%-assumption is reasonable for values of d that are neither too small nor too large.

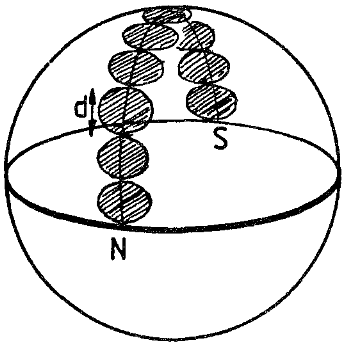

Figure 7 — A rough estimate.

We are first going to make a rough estimate of the probability that the backward prolongation of a sporadic meteor intersects the radiant. Therefore, imagine the entire visible part of the observer's meridian to be covered with "touching" radiants, as in Figure 6. Then each meteor will move along a great circle intersecting at least one of these radiants. Assuming that each radiant point contributes equally to what the observer sees (which is not true) and that no meteor moves along a great circle intersecting two or more radiants (which is not true either), we can roughly estimate the probability that such a great circle intersects the radiant in the zenith at $d/180°$, or, according to the assumption made above, the probability that a meteor is classified as belonging to that stream, at $d/360°$.

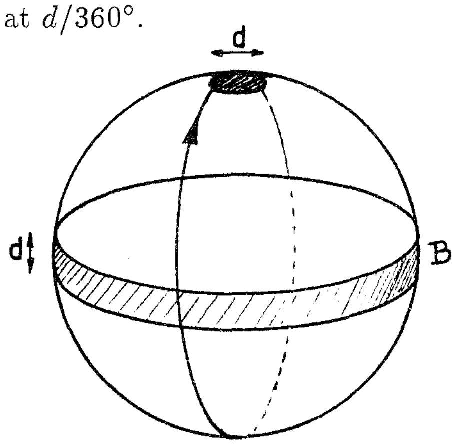

Figure 8 — The set of point in the sample space corresponding to sporadic meteors moving along great circles intersecting the radiant area.

Let us now refine the calculation. First, we calculate the probability that a meteor moves along a great circle intersecting the radiant area (in either of both directions). This compound event corresponds in the sample space to a belt B with diameter d, centered around the horizon, as can be seen in Figure 8. The probability of this event can now be computed as (all angles in rad):

$$\begin{aligned}\iint_B f\,dS &= \int_{A=0}^{2\pi}\int_{Z=\frac{\pi}{2}-\frac{d}{2}}^{\frac{\pi}{2}+\frac{d}{2}} f(Z,A)\sin Z\,dZ\,dA \\ &= 2\pi\frac{1}{\pi^2}\int_{\frac{\pi}{2}-\frac{d}{2}}^{\frac{\pi}{2}+\frac{d}{2}} \sin^2 Z\,dZ \\ &= \frac{d}{\pi}+\frac{2}{\pi}\cos\frac{d}{2}\sin\frac{d}{2}\end{aligned}$$

Notice that the result equals 0 for $d=0$ and 1 for $d=\pi$, as should be the case. Assuming that half of the meteors included in the above calculation move in the right direction for being classified as a member of the stream under consideration, we obtain a final probability of:

$$\frac{d}{2\pi}+\frac{1}{\pi}\cos\frac{d}{2}\sin\frac{d}{2}$$

Since d is small, we can put $\cos(d/2)\approx 1$ and $\sin(d/2)\approx d/2$ rad, yielding a value of d/π, or, in degrees, $d/180°$, twice the value of our earlier rough estimate.

5. The case of an arbitrary radiant

We are now considering a radiant with a zenith distance ε (see Figure 9). In order to calculate the probability that a meteor moves along a great circle intersecting the radiant area, we still have to calculate:

$$\iint_B f\,dS \tag{1}$$

In order to be able to describe B properly, we use coordinates Δ (radiant distance and α, as shown in Figure 9.

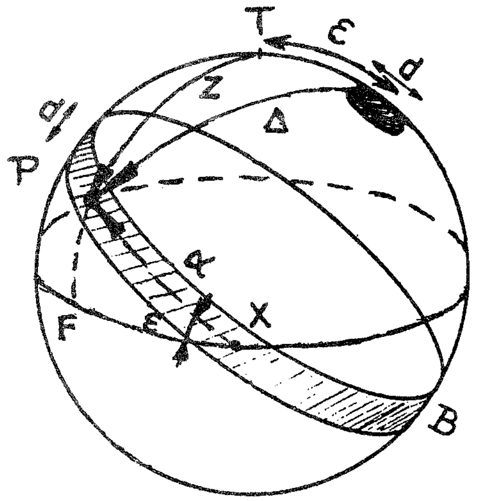

Figure 9 — The case of an arbitrary radiant

Then (1) can be rewritten as (all angles in rad):

$$\int_{\alpha=0}^{2\pi}\int_{\Delta=\frac{\pi}{2}-\frac{d}{2}}^{\frac{\pi}{2}+\frac{d}{2}} f(\Delta,\alpha)\sin\Delta d\Delta d\alpha \qquad (2)$$

Contrary to the previous case, f in (2) explicitly depends on both Δ *and* α. In order to keep the calculation tractable, we are going to replace $f(\Delta,\alpha)$ in (2) by $f(\pi/2,\alpha)$, which is a good approximation for small values of d. (2) can then be simplified to:

$$\int_0^{2\pi} f(\frac{\pi}{2},\alpha)d\alpha \int_{\frac{\pi}{2}-\frac{d}{2}}^{\frac{\pi}{2}+\frac{d}{2}} \sin\Delta d\Delta \qquad (2')$$

which equals:

$$2\sin\frac{d}{2}\int_0^{2\pi} f(\frac{\pi}{2},\alpha)d\alpha \qquad (3)$$

If Z is the zenith distance corresponding to coordinates $(0,\alpha)$, we have in the rectangular spheric triangle FPX: $\sin(\pi/2-Z)=\sin\varepsilon\sin\alpha$, or, $\cos Z=\sin\varepsilon\sin\alpha$, whence:

$$\begin{aligned} f(\frac{\pi}{2},\alpha) &= \frac{1}{\pi^2}\sin Z \\ &= \frac{1}{\pi^2}\sqrt{1-\sin^2\varepsilon\sin^2\alpha} \end{aligned} \qquad (4)$$

Substitution of (4) in (3) yields:

$$\begin{aligned} \iint_B f dS &= 2\sin\frac{d}{2}.\frac{1}{\pi^2}\int_0^{2\pi}\sqrt{1-\sin^2\varepsilon\sin^2\alpha}d\alpha \\ &= \frac{8}{\pi^2}\sin\frac{d}{2}\int_0^{\frac{\pi}{2}}\sqrt{1-\sin^2\varepsilon\sin^2\alpha}d\alpha \end{aligned} \qquad (5)$$

The integral in (5) is a so-called *elliptic integral*. The result of an elliptic integral cannot be written as a closed expression, but it can be developed in a power series:

$$\int_0^{\frac{\pi}{2}}\sqrt{1-k^2\sin^2 x}dx = \frac{\pi}{2}\left[1-\left(\frac{1}{2}\right)^2 k^2-\frac{1}{3}\left(\frac{1}{2}.\frac{3}{4}\right)^2 k^4-\frac{1}{5}\left(\frac{1}{2}.\frac{3}{4}.\frac{5}{6}\right)^2 k^6-\dots\right]$$

Hence the right-hand side of (5) can be rewritten as:

$$\frac{4}{\pi}\sin\frac{d}{2}\left[1-\frac{1}{4}\sin^2\varepsilon-\frac{3}{64}\sin^4\varepsilon-\frac{5}{256}\sin^6\varepsilon-\dots\right] \qquad (6)$$

In order to calculate the desired probability we have to divide (6) by a factor 2 to account for the meteor direction. For d small, and switching to degrees, this finally yields:

$$\frac{d}{180°}\left[1-\frac{1}{4}\sin^2\varepsilon-\frac{3}{64}\sin^4\varepsilon-\frac{5}{256}\sin^6\varepsilon-\dots\right] \qquad (7)$$

The probability is expressed as a fraction of $d/180°$. In Table 1, below, we calculated these fractions for some values of ε, the zenith distance of the radiant.

Table 1 – The probability p for a sporadic meteor to be classified as a stream member in function of the zenith distance ε of the radiant. The probability is expressed as a fraction of $d/180°$.

ε	p	ε	p
0°	1.00	60°	0.78
30°	0.93	75°	0.71
45°	0.86	90°	0.68

We may conclude that the elevation of the radiant has little influence on the probability of a sporadic meteor being classified as originating from that radiant. The probability is never below 68% of the value obtained for a radiant in the zenith. Except for very low elevations of the radiant, which yield poorly reliable data anyway because of the large correction factor for the ZHR, we may even say that p does not differ significantly from 1, as far as order of magnitude is concerned.

6. Conclusions

From the above, we may conclude that the probability for a sporadic meteor to be classified as a stream member is about $d/180°$. For the most experienced observers in the world, d is about 3°.5 to 5°, depending on the relative position of the radiant and the center of the observer's field. For average experienced observers, we may put $d \approx 7°.5$. For these observers, the above probability equals 4%. If we take a value of 15 for the sporadic HR, then it follows that the "pollution" of the stream ZHR amounts to a value of about 0.6.

This value does not take into account several effects common during visual observations. For instance, the relative position of a meteor and the center of the observer's field can be unfavorable; or the concentration of the observer may have decreased on the moment a meteor appears. All these effects have as a consequence that the observer cannot always accurately determine the position of a meteor trail relative to the background stars. Usually, the observer will tend to use this inaccuracy in favor of stream classification.[2] Therefore, we think it is safe to conjecture that stream ZHRs should be lowered by 1 to account for the "sporadic pollution".

As a consequence, it makes little sense to try to detect minor showers with (observed) ZHRs less than say about 3, using one station visual observations. To distinguish such minor showers, one should either observe telescopically (if the mass distributions of the showers allow it) or simultaneously (preferably photographically). At the same time, we should also warn for trying to distinguish major showers at the very beginning or end of their activity period. Only when ZHRs rise above 3, visual observations become significant. Finally, we have to warn for false conclusions concerning the average magnitudes of r-values of minor showers, and of major showers at the beginning or the end of their activity period, as they may have been biased by sporadic pollution.

References

[1] W.F. Denning, "General Catalogue of the Radiant Points of Meteoric Showers", *Mem. R.A.S.* 53, 1899.

[2] A.F. Cook, "A working list of meteor streams", *Evolutionary and physical properties of meteors*, NASA, Washington DC, 1973, pp. 183–191..

[3] R.A. Mackenzie, "BMS Radiant Catalogue", British Meteor Society, 1981.

[2] The value of the effective radiant diameter d only takes into account errors in backward prolongation of meteor trails.

The Effect of Experience on Amateur Visual Meteor Observations

David Gatt

It is a well-known phenomenon that the characteristics of meteor showers observed by different observers are often different, in spite of applying corrections for variation of the observing conditions. These intrinsic differences are commonly lumped together under the term "Human Factor". The purpose of this study is to investigate the effect, if any, of the observers experience on these differences between observers.

1. Methods and data

The data for this study was collected during a three-week observation of the 1988 Perseid meteor shower organized by the *Astronomical Society of Malta*. In particular, a one-week residential camp was held over the period August 6–7 to 12–13 when mixed groups of experienced and inexperienced observers made simultaneous watches. The 27 contributing observers were:

> Stephen Abela (SA), Neville Aquilina (NA), Anna Baldacchino (AnB),Godfrey Baldacchino (GB), Stephen Brincat (SB), Bernard Bonnici (BB), Edwin Camilleri (EC), Yosanne Cini (YC), Chris Carabot (CCr), Martin Debattista (MD), Marcel Farrugia (MF), Adrian Galea (AdG), Alex Gambin (AlG), David Gatt (DG), Franco Gatt (FG), Pierre Gatt (PG), Eileen Grech (Eig), Edwin Grech (EdG), Antoine Grima (AnG), Sandro Lanfranco (SLf), Jean Paul Mifsud (JPM), James Mizzi (JMz), Gordon Pace (GP), David Pace (DP), James Sammut (JS), Mark Scicluna (MS), Leslie Vella (LV).

Experience has been defined in terms of the number of meteors recorded by each observer. This data was collected from reports compiled by the society for those meteors observed prior to the start of the project. To this was added half the total number of meteors observed during this project, to give a value for the average experience of each observer for the period of the experiment. These values for meteor count experience (E) are shown in Table 1.

2. Analysis of the magnitude data

Mean magnitudes:

For each individual observer, the mean magnitudes for the shower and sporadic meteors were calculated. Absolute shower magnitude[1] was also computed. These values are shown in Table 1.

Linear regression analysis was performed on the relationship between mean magnitudes and experience, and the relevant statistics are shown in Table 2.

It will be seen there is a weak but significant correlation for the mean magnitudes $M_{\rm sh}$ and $M_{\rm sp}$ of shower meteors respectively sporadics; in both cases the more experienced observers report fainter values. On the other hand, for $M_{\rm abs}$ there is a negative correlation. The more experienced observers report brighter absolute mean shower magnitude. This is to be expected from the first two results, since the slope for the $M_{\rm sh}$ correlation is less than for the $M_{\rm sp}$ correlation. In effect, the less experienced observers are overestimating (reporting too bright a value for) the $M_{\rm sp}$ to a greater extent than the $M_{\rm sh}$. A possible explanation is that some shower or minor shower meteors may be inadvertently classed as sporadics by the inexperienced observers.

[1] $M_{\rm abs} = M_{\rm sh} - M_{\rm sp} + 3.25$

Table 1 – Statistics for mean magnitudes.

		Shower			Sporadic			M_{abs}
Obs	E	N	M	Var	N	M	Var	M_{abs}
GB	2382	123	1.29	4.58	110	2.42	3.08	2.12
Adg	1177	466	1.03	2.50	330	2.26	2.20	2.02
DG	1136	137	1.39	3.26	34	1.97	2.97	2.67
AnB	747	116	0.64	4.01	64	2.08	2.48	1.81
BB	666	382	0.92	2.64	99	1.78	1.79	2.39
EiG	656	301	1.67	2.74	142	1.92	2.22	3.00
SA	590	170	1.09	2.75	128	1.73	2.84	2.60
AlG	498	212	0.70	3.13	74	1.42	2.59	2.53
AnG	419	429	0.70	3.79	209	2.08	3.49	1.88
JPM	370	60	0.97	3.00	31	1.39	1.79	2.83
LV	356	52	0.79	2.44	21	1.33	1.17	2.71
GP	355	217	0.21	3.61	129	1.07	3.29	2.39
EdG	333	176	1.35	1.44	62	1.81	1.29	2.79
MD	304	118	1.60	2.68	152	2.67	1.73	2.18
JMz	204	237	0.57	3.36	98	1.80	3.02	2.02
SB	198	98	1.72	1.77	7	2.57	1.39	2.40
YC	184	29	0.59	3.28	18	0.78	3.73	3.06
EC	144	123	0.39	2.47	96	1.30	2.92	2.34
CCr	140	92	0.97	3.14	65	2.15	2.53	2.06
MS	137	44	−0.14	3.16	37	0.00	3.14	3.11
SLf	124	129	1.02	2.04	62	1.79	1.78	2.48
DP	88	18	1.06	4.05	3	2.00	0.67	2.31
FG	70	96	0.23	4.11	31	1.32	2.09	2.16
NA	65	109	−0.17	2.73	18	−0.56	3.25	3.63
PG	48	48	0.46	0.71	31	0.61	1.53	3.10
MF	24	12	2.17	3.81	8	2.00	3.50	3.42
JS	14	8	1.50	2.75	10	2.30	1.81	2.45

Table 2 – Linear regression parameters for mean meteor magnitudes.

	Slope	Intercept	R	P
M_{sh}	+0.0002354	0.816	+0.208	0.15
M_{sp}	+0.0005786	1.391	+0.382	< 0.05
M_{abs}	−0.0003421	2.673	−0.362	< 0.05

Inspection suggests that the values reported by inexperienced observers also show more variability than those reported by experienced observers. In other words there is better agreement amongst experienced observers than inexperienced observers. To test this hypothesis, the observers were divided into two groups the dividing criterion being $E \geq 450$ or $E < 450$ meteors. We chose this value, because starting from $E = 450$, one can find a sharp tendency for the reported means to converge. Furthermore this value was coincidentally found to split the total number of meteors observed into two, approximately equal samples. The variance of the two populations was calculated and *Snedecor's F-test*[2] was applied. It was found that the differences are significant for $M_{\rm sh}$ ($P < 0.05$) and $M_{\rm sp}$ ($P < 0.01$), whereas significance was not achieved for $M_{\rm abs}$ ($P > 0.05$).

[2] a standard test for significance of difference between sample variations.

Magnitude variance:

The values for magnitude variance for each observer were also calculated (see Table 1) and analyzed in a similar manner to that described above. The statistics for linear regression are shown in Table 3.

Table 3 – Linear regression parameters for meteor magnitudes variance.

	Slope	Intercept	R	P
Var(Sh)	+0.0006263	2.702	+0.359	< 0.05
Var(Sp)	+0.0001476	2.307	+0.091	$\gg 0.05$

A weak correlation is again noted, more marked for the shower distribution, although that for sporadics does not achieve significance. Also, a close inspection similarly suggests convergence to a mean value with increasing experience as was noted for magnitudes above. Snedecor's F test supports this for sporadic ($P < 0.05$) but not for shower meteors ($P > 0.05$). Thus, inexperienced observers seem to report less meteors at the extremes of the magnitude range, and again there is a closer agreement amongst the more experienced observers.

Comparison of pooled mean magnitudes:

Pooling together all the magnitude estimates recorded, statistics for the magnitude distributions were calculated for shower and sporadic meteors. Statistics were also derived for those meteors recorded by inexperienced observers ($E < 450$) and experienced observers ($E \geq 450$). The rationale for choosing 450 as the dividing line was explained above. The differences of the means of the two sub-populations are found to be very significant ($P < 0.001$) for both shower and sporadic meteors. One should note, however, that M_{abs} calculated for two groups is the same. We are thus led to believe that M_{abs} is almost independent of observer experience.

This last finding regarding M_{abs} may seem incompatible with the finding of correlations with observer experience noted above. It should, however, be remembered that this correlation was rather weak, and the variances for the groups $E < 450$ and $E \geq 450$ were not significantly different.

Simultaneous magnitude estimates:

In order to investigate in greater detail the differences in magnitude estimates between different observers, the magnitudes assigned to the same meteor seen by different observers were analyzed. Identification of the same meteor seen by different observers was possible because the meteor designation was assigned by each group's time-keeper.

For any meteor observed by two or more observers the magnitude values assigned by each were arranged in order of descending observer experience. Every possible pair of values was then taken and the differences calculated, always subtracting the value given by the less experienced observer from that given by the more experienced.

If there is no systematic difference in magnitude estimates depending on observer experience, the calculated differences should be symmetrically distributed around zero and their mean should not differ significantly from zero. If, however, experience influences the magnitude estimate, since the pairs were arranged in order of experience, the mean of the differences will be significantly different from zero.

It will be seen from Table 4 that when all the magnitude estimates are pooled together, there is no significant difference. However, when the estimates are grouped by magnitude class (mean magnitude estimate) then the following differences are noted:

- for very bright meteors ($M < 0$) there is a significant tendency for the less experienced observers to report a fainter magnitude;
- for $0 \leq M < 1$ meteors there is no significant difference;
- for $1 \leq M < 2$ the experienced tend to report a brighter magnitude; and

- for $M \geq 2$ there is no significant difference.

Table 4 – Statistics for differences of simultaneous magnitude estimates.

Class	N	M	P
all	2707	+0.020	> 0.05
$M < 0$	766	−0.120	< 0.05
$0 \leq M < 1$	637	−0.058	> 0.05
$1 \leq M < 2$	678	+0.189	< 0.01
$M \geq 2$	626	+0.089	> 0.05

There thus seems to be a certain tendency for the less experienced observers to report meteor magnitudes in the mid-range. This is in keeping with the effect of experience on magnitude variance noted above at least for shower meteors.

The faintest magnitude class seems anomalous in that, although the mean of the differences is of the correct sign to support the above hypothesis, it is neither as marked as significant. A possible explanation for this is that as the meteors reported become fainter, the observer has an additional aid in estimating its magnitude (the stellar limiting magnitude), and this partially corrects the tendency towards the mid-values suggested above.

The tendency of inexperienced observers to overestimate (i.e. report as too bright) the magnitudes of faint meteors could also explain, at least in part, the tendency for their estimate of mean magnitude to be too bright: since there are more faint meteors than bright ones, the mean magnitude reported by the less experienced observers would be too bright.

3. Coefficients of perception

Table 5 – Coefficients of perception

Obs	E	RHR	RShR	RSpR	RMSR	ZHR	HR
GB	2382	0.93	0.90	1.15	0.56	1.00	1.13
AdG	1177	1.11	1.06	1.07	1.55	0.95	0.89
DG	1136	0.99	1.20	0.67	0.51	1.23	0.70
AnB	747	0.69	0.71	0.63	0.73	0.68	0.55
BB	666	1.02	1.21	0.66	1.10	1.31	0.63
EiG	656	1.35	1.43	1.58	0.02	1.56	1.74
AlG	498	0.94	1.00	0.58	1.52	0.82	0.46
AnG	419	1.07	1.22	0.81	1.11	1.15	0.70
JPM	370	0.61	0.67	0.66	0.00	0.80	0.69
GP	355	1.01	0.93	1.45	0.00	1.30	2.67
EdG	333	1.14	1.17	1.16	0.79	1.20	1.21
MD	304	1.14	0.87	1.60	1.42	1.07	1.56
JMz	204	0.98	0.93	1.07	0.99	0.89	1.04
SB	198	0.71	0.81	0.17	0.00	0.76	0.16
EC	144	1.04	1.01	1.27	0.59	0.99	1.41
CCr	140	0.95	0.74	1.48	1.08	0.61	1.10
MS	137	0.81	0.82	0.83	0.74	0.75	0.81
SLf	124	0.99	0.83	0.92	2.30	0.60	0.60
FG	70	0.98	1.04	0.91	0.82	1.47	1.33
NA	65	1.15	1.27	0.79	0.65	0.73	0.53
PG	48	0.82	0.77	0.74	1.19	1.17	1.36

Throughout the period of the experiment, observations were performed by groups consisting of relatively experienced and relatively inexperienced observers. For each watch a coefficient of perception (CP) was calculated by taking the meteor activity reported by each observer divided by the mean activity reported by the whole group. For each observer a grand mean CP was then calculated, weighted by the average meteor activity reported during the watch on which each CP was based. The above procedure was performed for each of the following measures of meteor activity: raw hourly rate (RHR), raw shower hourly rate (RShR), raw sporadic hourly rate (RSpR), raw minor shower hourly rate (RMSR), ZHR and HR.

The rationale for taking the first four measures of CP was to try and establish not only the observers' intrinsic ability to detect meteors, but also if there existed a difference in their abilities to correctly classify meteors. A comparison of ZHR- and HR-CP was performed to try and demonstrate a systematic error in overestimating the various correction factors (in effect the only correction estimated subjectively was the one for star limiting magnitude). The various values are shown in Table 5.

Linear regression analysis was attempted for the relationships between the various CPs and observer experience; relevant statistics are shown in Table 6.

Table 6 – Linear regression parameters for perception coefficients.

CP	Slope	Intercept	R	P
RHR	+0.00001632	0.965	+0.051	$\gg 0.05$
RShR	+0.00005120	0.956	+0.134	$\gg 0.05$
RSpR	+0.00003405	0.945	+0.050	$\gg 0.05$
RMSR	−0.00010710	0.893	−0.099	$\gg 0.05$
ZHR	+0.00007193	0.967	+0.140	$\gg 0.05$
HR	−0.00003650	1.031	−0.036	$\gg 0.05$

It will be seen that there is no significant correlation. Comparing the variances of the groups for $E < 450$ and $E \geq 450$ also shows no significant difference ($P > 0.05$).

It would thus seem that observer experience plays little role in affecting an observer's coefficient of perception, or at least, such effect is too small to be detected by the data available. It should be pointed out that each group was quite small and there was some change in the composition of the groups from night to night. This introduced another source of variability which might have obscured the effect being searched for. Furthermore, some of the observers consulted others as to the classification of various meteors, invalidating any attempts to analyze the ability to classify meteors.

An attempt was also made to detect any correlation between CP for each individual observer as his experience increased throughout the experiment, but again no correlation could be established.

4. Star limiting magnitude (Lm)

The effect of observer experience on Lm estimates was also investigated. In each of the groups watching, each observer was asked to make a number of Lm estimations. Every member of the group made the estimate at the same time. Estimates were made using the star count method whereby limiting magnitude is derived by counting the number of stars visible in an area bounded by a polygon of stars. The Lm is then obtained by consulting tables published for each area.

In the first instance these simultaneous estimates were analyzed in a manner analogous to that described above for the simultaneous magnitude estimates. No systematic difference could be demonstrated (see Table 7).

Table 7 – Statistics for differences of simultaneous Lm estimates.

Class	N	M	P
all	885	+0.006	> 0.05

For each estimate, the difference between the group mean and the individual observer's estimate was calculated and then a mean value of the Lm error was obtained for each observer (Error). These values were related with experience (Table 8) and linear regression was performed (Table 9).

Table 8 – Mean errors of Lm estimates.

Obs	GB	AdG	DG	AnB	BB	EiG	AlG	AnG	JPM	GP
E	2382	1177	1136	747	666	656	498	419	370	355
Error	+0.0351	−0.0121	+0.0458	−0.0963	−0.0703	+0.0941	−0.1199	−0.0563	+0.3019	+0.3809
Obs	EdG	MD	JMz	EC	CCr	MS	SLf	FG	NA	PG
E	333	304	204	144	140	137	124	70	65	48
Error	+0.0206	+0.0790	−0.0415	−0.0085	−0.3159	−0.0733	−0.4021	+0.3139	+0.2689	+0.4999

Table 9 – Linear regression parameters for mean Lm error and modulus (or absolute value) of mean Lm error.

	Slope	Intercept	R	P
Error	−0.00003648	0.060	−0.091	$\gg 0.05$
|Error|	−0.00012800	0.226	−0.459	< 0.05

No correlation was established. However, if variances for the groups $E < 450$ and $E \geq 450$ are compared by Snedecor's F-test, the difference is found to be very significant ($P < 0.01$). Furthermore, if linear regression analysis is repeated with the modulus (or absolute values) of the Lm errors, a significant negative correlation is established.

These findings imply that the more experienced observers are able to give more reliable estimates of the Lm, but there is no systematicity in the error made by less experienced observers.

5. Conclusions and comments

In summary the main conclusions of this study are the following:

- There are significant differences in the mean shower and sporadic magnitudes reported by groups of experienced and inexperienced observers. Mean absolute shower magnitude however, seems fairly immune to this effect and should be calculated whenever possible.
- Increasing experience improves the agreement between mean magnitude estimates for different observers, with a lesser effect on the mean value reported. Thus, the error range for results obtained by experienced observers will be much smaller than for inexperienced ones.
- Increasing experience improves the agreement between Lm estimates for different observers, with a lesser effect on the mean value reported. The reason for this difference may lie either in the less experience observers misunderstanding the method (most commonly excluding the corner stars in the star count method, failing to correctly identify the area boundaries, or actually not perceiving the faintest stars). The actual source of discrepancies may require further investigation to help devise a more reliable method of estimating the Lm.

- Less experienced observers' estimates of meteor magnitude tends toward the midrange (i.e. underestimating the bright meteors and overestimating the faint ones). This tendency may at least partially explain the tendency for inexperienced observers to report too bright a mean magnitude.
- Observers experience has little effect on observers' coefficients of perception. Simultaneous experiments with much larger groups may, however, be able to demonstrate such differences.

Assuming the above results are applicable generally, it would seem advisable to utilize only those observations submitted by observers with a certain degree of experience for international pooling and analysis. This is especially important regarding magnitude data. Much work still needs to be done in identifying the other causes of variability between meteor observers, several of which clearly do not depend on observer experience. Until the source of this variability is properly investigated, reliable results for visual meteor work must rely on pooling the information of as many experienced observers as possible.

The Geminid Meteor Stream in 1988

Paul Roggemans

Global observations on the Geminids in 1988 yielded 14 193 Geminids used in 668 Zenithal Hourly Rates. The averaged activity profile shows a secondary maximum of 50 meteors an hour at $\lambda_\odot = 259\overset{\circ}{.}9 \pm 0\overset{\circ}{.}1$. The main maximum covers 14 hours, starting at $\lambda_\odot = 260\overset{\circ}{.}85$ peaking at $\lambda_\odot = 261\overset{\circ}{.}38 \pm 0\overset{\circ}{.}08$ with 120 meteors per hour and ending at $\lambda_\odot = 261\overset{\circ}{.}6$. The activity profile is characterized by a steep decrease immediately after the maximum peak: the Geminid activity dies out in about 24 hours.

1. Introduction

For years now, the Geminids are considered to be the richest annual meteor shower. For this reason amateurs would be expected to observe during the nights around the maximum of December 13–14 with great enthusiasm. However, the spectacular activity of this shower fails to get most meteor workers out at night. Past years saw rather few efforts reported on the Geminids. Only 20 to 30 percent of the annual Perseid watchers contribute with observational efforts to the Geminid watches.

The Geminids are a very recent appearance on Earth. No reports can be found for the Geminids prior to the 19th century. Geminid rates in the mid 19th century were very low to moderate and by no means comparable to the Perseids, at that time known as the most productive stream. Only some individual reports at the turn of the century indicated that the stream became much more active than at its discovery. By the 1920ties rates were often close to 100 Geminids per hour. Very few reports are available and conclusions for these decades are based on a very small number of individual reports. The history of the Geminids has been described in [1].

Well covered Geminid years are very scarce and only during the recent few years some more detailed analysis of the Geminids became possible [2,3,4,5].

1988 broke all records as the original *VMDB* data contained 441 observations, covering 8445 Geminids (15 686 meteors in total). As the contributions came from about one week of observing in North America, Australia and Europe, a very complete coverage of the Geminid activity in 1988 was obtained. Never before a complete analysis such as in this report had been possible. This report illustrates once again the importance of a database run by *IMO*. The *VMDB* can easily handle more data. We sincerely hope that observers who did not yet forward observations to the *VMDB* will do so in the future. Negotiations with Soviet, Hungarian, Czechoslovakian and South American meteor observers will hopefully convince these people to increase the statistical significance of the *VMDB* results. If you read this, and when you have visual results, please send us your report and make sure to get your data timely into the *VMDB*!

Hiroyuki Tomioka reported us very good Japanese results. The Nippon Meteor Society uses the same ZHR definition as *IMO*. No Japanese raw data in the *VMDB* hourly rate format is available thus far, but the ZHR-results from Japan could be appended to the ZHR file of the *VMDB*. Altogether the final file contained 668 ZHRs computed on 14193 Geminids reported by 109 different observers. These numbers are very impressive and represent a fantastic effort brought together by the following observers:

> T. Arakawa (ARAKT), Rainer Arlt (ARLRA), James Athanasou (ATHJA), Lance Benner (BENLA), Guy Blackman (BLAGU), Andrea Boattini (BOAAN), Peter Brown (BROPE), Paul Camilleri (CAMPA), Franco Canepari (CANFR), Maurice Clark (CLAMA), Matthew Clements (CLEMA), Louise Cockeram (COCLO), Martin Coroneos (CORMA), Luigi D'Argliano (D'ALU), Mark Davis (DAVMA), Stefano Del Dotto (DELST), Massimo Dionisi (DIOMA), John Drummond (DRUJO), Maurizio Eltri (ELTMA), Tom English (ENGTO), Kim Felstcad (FELKI), Yasunori Fujiwara (YASFU), K. Fukui (FUKUK), T. Fukuhara (FUKUT), Kai Gaarder (GAAKA), Massimo Giuntoli (GIUMA), Mark Glossop (GLOMA), Roberto Gorelli (GORRO), Guido Guidotti (GUIGU), Nicholas Harvey (HARNI), Takema Hashimoto (HASTA), Roberto Haver (HAVRO), Lars Trygve Heen (HEELA), Craig Hinton (HINCR), Daiyu Ito (ITODA), Kiyoshi Izumi (IZUKI), Toshio Kamimura (KAMTO), Norihito Kawamura (KAWHI), Junji Kawamura (KAWJU), Norihito Kawamuro (KAWNO), Y. Kikoku (KIKOY), André Knöfel (KNOAN), M. Kobayashi (KOBMA), Komatusaki (KOMAT), Kosiyama (KOSIN), Ralf Koschack (KOSRA), William Kuehne (KUEWI), Ralf Kuschnik (KUSRA), Alberto Latini (LATAL), Robert Lunsford (LUNRO), Alan MacRobert (MACAL), Kouji Maeda (MAEKO), Katsuhiko Mameta (MAMKA), Francisco Anton Marin (MARFR), Paul Martsching (MARPA), T. Maruyama (MARUT), Alastair McBeath (MCBAL), Fabrizio Melandri (MELFA), T. Miyazaki (MIYAT), H Mizoguchi (MIZHI), John Moody (MOOJO), Dina Moro (MORDI), Sabine Moritz (MORSA), Naomi Mutou (MUTNA), N. Muto (MUTON), T. Nagatuma (NAGAT), R. Narus (NARUS), Ali Nasri (NASAL), Seiko Nishioka (NISSE), K. Noze (NOZEK), M. Oka (OKAM), Alessandro Pieri (PIEAL), George Platt (PLAGE), Stefano Raffaelli (RAFST), Ina Rendtel (RENIN), Jürgen Rendtel (RENJU), Martino Rizzi (RIZMA), Paul Roggemans (ROGPA), Livio Rossani (ROSLI), Toru Sagayama (SAGTO), Kotaro Sakuma (SAKKO), H. Sato (SATOH), Francesca Scarra (SCAFR), Holger Seipelt (SEIHO), Yasuo Shiba (SHIYA), Y. Sikoku (SIKOY), Sindo (SINDO), K. Siotani (SIOTK), David Stine (STIDA), Enrico Stomeo (STOEN), Stefano Stomeo (STOST), Y. Suzuki (SUZUY), David Swann (SWADA), Richard Taibi (TAIRI), Jun Takada (TAKJU), Hiroyuki Tomioka (TOMHI), Toriyama (TORIY), Michelle Treasure (TREMI), Emiliano Trizio (TRIEM), José Trigo Rodriguez (TRIJO), Masayoshi Ueda (UEDMA), Toshihiko Ueno (UENTO), Yoshiaki Uyama (UYAYO), Mirco Villa (VILMI), Roger Vodicka (VODRO), William Walbek (WALWI), Jeff Wood (WOOJE), Nikolai Wunsche (WUNNI), Yasuo Yabu (YABYA).

To all these observers, thank you very much for the excellent work done. Be aware that these results would not have materialized without your dedicated effort.

2. The activity profile

The observational data was analyzed according to the method described in [4]. In total 441 ZHRs were computed from the *VMDB* (Japanese observations were added later on).

Figure 1 shows the individual results as they were computed by the *VMDB*. One may wonder why the scatter is so large. Figure 1 represents all data points without any omission. Very low values represent observations where the radiant was very low on the horizon, some other points were obtained in too short observing intervals or at poor sky.

Before the averaging process starts, observations are selected, removing ZHRs obtained with the radiant below the horizon. Next a quality selection is made by introducing a maximum for the correction factor used to compute the ZHR. A poor limiting magnitude combined with a large zenith distance correction may easily yield a factor of 5 or more. The observer can compensate for this by observing longer, increasing T_{eff}. In general, the maximum correction factor allowed in reports like this is 5. In some cases the upper limit was put at 3. As soon as the ZHRs obtained with a correction factor larger than 5 are removed, the large spread of Figure 1 becomes much less discouraging. Some spreading on the ZHR at a given instant will be always present, as we can expect from the nature of a meteor count. The statistical variation on the ZHR enables us to make a mere estimate of the activity. The most likely activity profile will be found when many independent estimates of the activity are available.

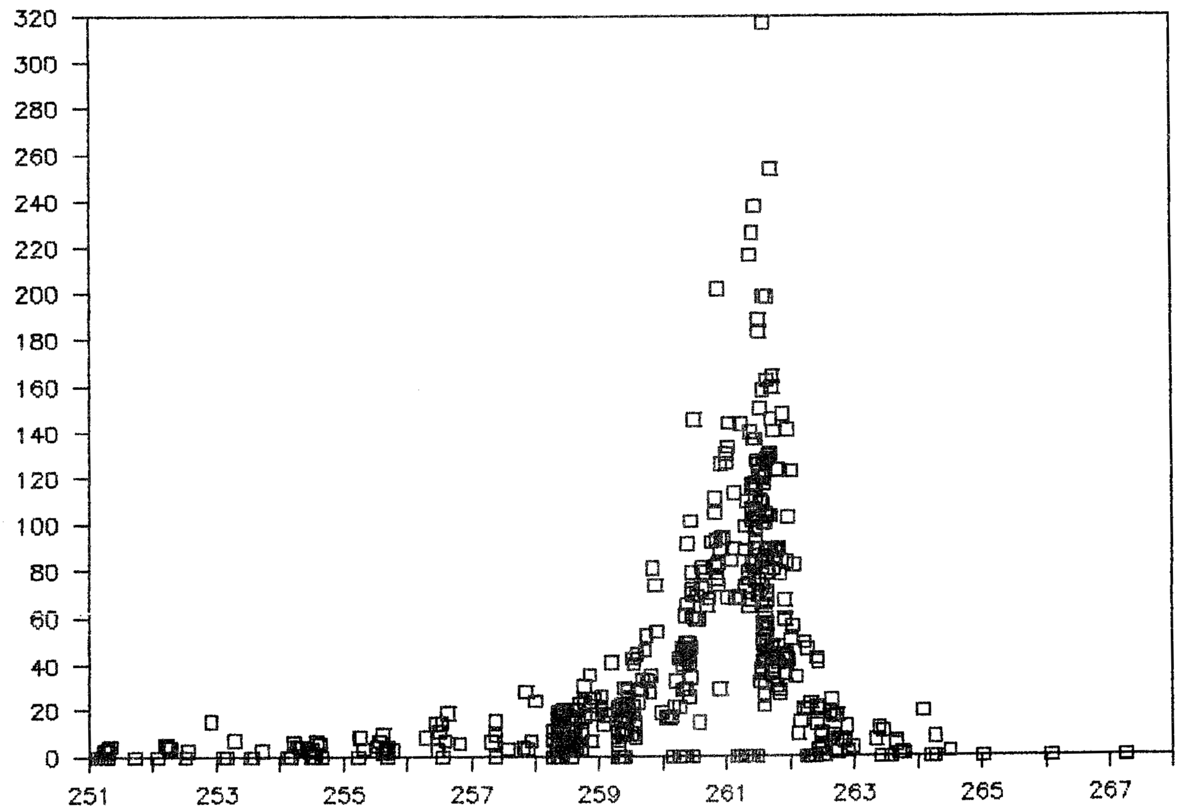

Figure 1 – Individual ZHRs computed by the *VMDB* for individual observers in America, Australia and Europe.

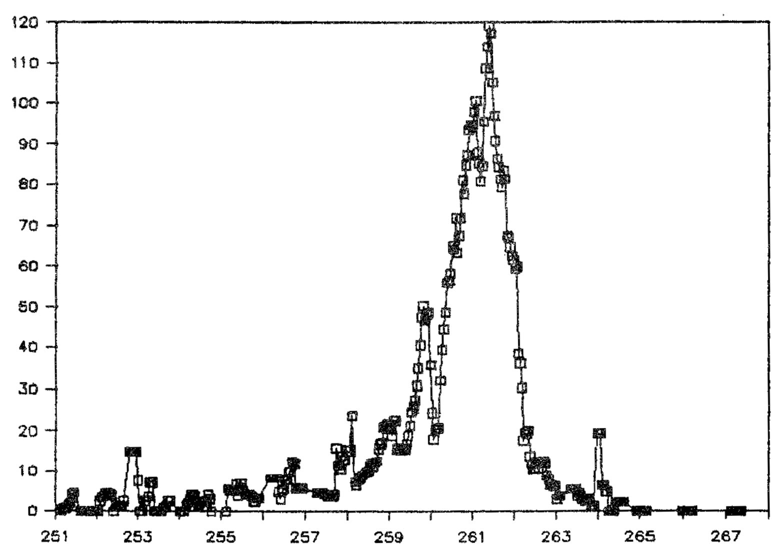

Figure 2 – Averaged ZHR-curve of the 1988 Geminids, using a sliding mean over a 6 hour period by a step of one hour.

One factor is not yet compensated for in these analyses: perception. Some observers have better eyes and count considerably more meteors than their colleagues. When a large number of observers contribute to a report such as this, the low perception observers may be expected to be compensated by the higher perception observers. The *VMDB* enables us to find a perception coefficient for each observer.

When results are averaged, the activity profile shows a quite smooth shape. From Figure 2 we see that the activity gets up from the zero level at $\lambda_\odot = 251°$ (December 3), to about 10 at 258° (December 10). The small variations illustrate how rates fluctuate with hours without a Geminid seen, and hours with five to ten Geminids appearing the week before the maximum. If more observers were active in that period, rates were probably smoothly going upwards.

From $\lambda_\odot = 258°$ the Geminid activity starts its rise towards maximum level. If you do not want to miss anything, this is the night to start with: December 10–11. Rates get gradually up to 20. European observers witnessed a steep increase in hourly rates on December 11–12, getting up to a ZHR of about 50 at $\lambda_\odot = 259\overset{\circ}{.}9 \pm 0\overset{\circ}{.}1$. This seemed most promising for the maximum night in Europe, although some observers worried that the maximum might occur too early, being over when Europe would have nighttime from December 13 to 14. American observers started with good rates, but the second part of the American observing window saw much lower rates. Australians took up at $\lambda_\odot = 260\overset{\circ}{.}15$ and saw rates increasing again gradually.

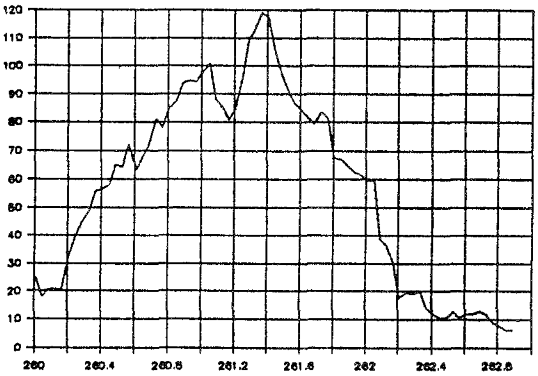

Figure 3 — Enlargement of Figue 2 around maximum.

Figure 3 enables us to look closer at the curve near the maximum and to read more carefully the solar longitudes of the maximum. The Geminid hourly rates increase very smoothly from $\lambda_\odot = 260\overset{\circ}{.}2$ (ZHR 20) to $261\overset{\circ}{.}05$ when the mean ZHR reached 100. Then something rather remarkable happened: rates decreased back to about 80 at $\lambda_\odot = 261\overset{\circ}{.}2$, just at the end of the American observing window and at the start of the Australian Geminid watch. The maximum is then reached at $\lambda_\odot = 261\overset{\circ}{.}36$ with a ZHR of 119. This high maximum level was observed in Japan and Australia. When the Europeans took over for their maximum night, all they got was a rather steeply declining hourly rate.

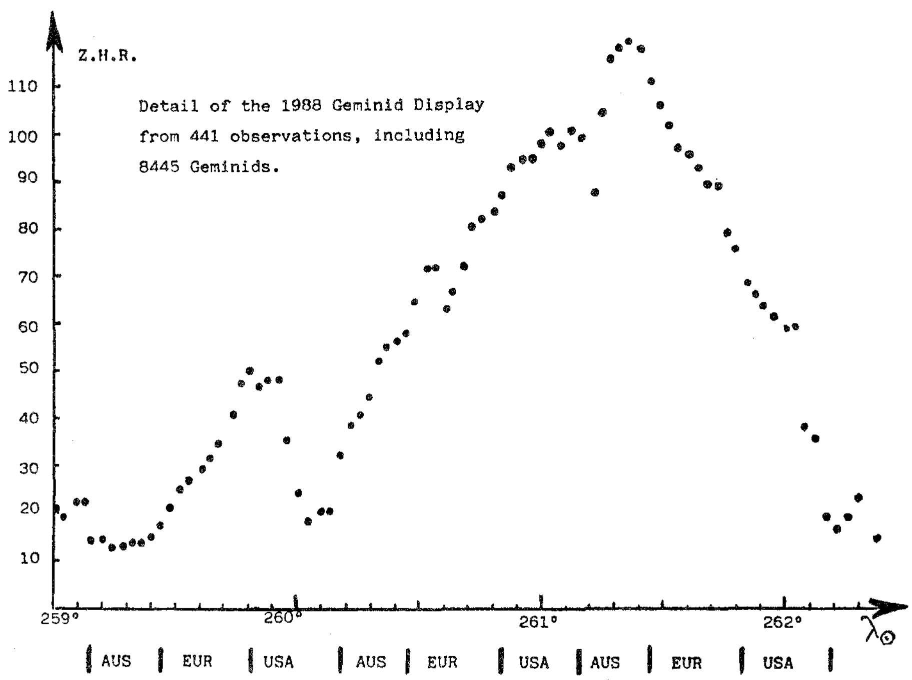

Figure 4 – Detail of the Geminid activity, averaged over a 6 hour period, one average every hour.

The evening started with remarkably long Geminid trails striking through the sky from a very low radiant somewhere near the horizon. When the radiant got higher rates became better, but experienced Geminid watchers knew that they were observing the declining activity of a good maximum that was over when the radiant got high enough in the sky. When Americans took over, rates were at less than 50% of the maximum level. The decrease from the maximum ZHR of 120 to the level of 20 took only one day! The following night, Australian and European people saw barely a few Geminids: a boring experience. By December 16, Geminids are almost non-existent.

Some very high and some very low ZHRs were eliminated before the ZHRs were averaged again to draw Figure 4. The high activity level at $\lambda_\odot = 259^\circ\!.8$ remains and the general shape does not change much. The dip at $\lambda_\odot = 261^\circ\!.2$ is only represented by one data point. At that time Robert Lunsford was watching, and confirmation from more observers is required before the dip can be explained. The time of the main maximum remains however as it was seen entirely to the Australian teams.

3. Some discussion

An activity profile of a stream should picture us the particle density variation through a cross-section of that stream. A question we should ask ourselves is which resolution we can get in the cross-section picture? Where do the real density features end and at which point do spurious features get involved? One may suggest to add error bars to the graphs. At this stage of the *VMDB* we are not sure yet which error definition can be considered representative on the data points. Observers from Malta (G. Baldacchino) and George Spalding use the probable error ZHR/$\sqrt{N}$. However, if you wish to use this error margin with the large quantities involved in the *VMDB*, the thickness of the data points include the error bars in most cases. Obviously, the probable error is larger! When we compute the mean ZHR, we also compute the standard deviation on the average, just to give you an idea of the spread on the mean ZHR. This standard deviation is much larger than the real uncertainty on the ZHR. It is mostly due to the differences in perception, and, in case that the sampling period is too long, to the rapidly changing activity itself. For this reason, long averaging periods of 12 hour and more are unsuitable as the standard deviation may then increase a lot. For instance the decrease after the Geminid maximum goes very steeply in very few hours.

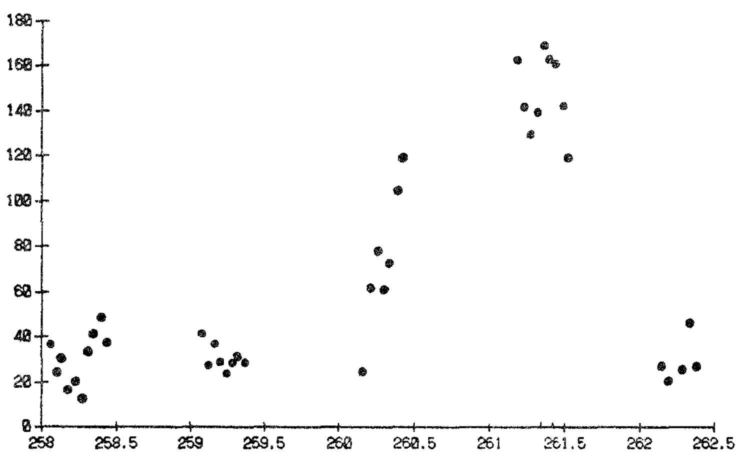

Figure 5 – Averaged 1989 Geminid ZHRs observed in Japan, computed by H. Tomioka.

Up to now, *IMO* has not yet introduced a perception coefficient for each observer. This means that we assume that we have so many observers, that too high perceptions are averaged out against too low perceptions. This assumption is not necessarily true. In case we would get a peak-value due to the presence of high perceptive observers only, and thus a spurious peak, then the standard deviation will be very small as small differences will occur among the ZHRs, being all grouped at the upper part of the perception scale. Yet, the sporadic hourly rate may help to detect such coincidences. The question how to obtain the most realistic error presentation on the averaged ZHRs remains to be answered and may be a topic to be studied by some *IMO* members.

Another way to get some more confidence in the activity profiles is to compare the results to these of another group that worked independently from *IMO*. Mr. Hiroyuki Tomioka (founding member of *IMO*) published a very impressive report in [6]. His averaged results are shown in Figure 5.

The observations were all done in Japan by members of the *Nippon Meteor Society (NMS)*. The methods and ZHR definition are identical to *IMO*'s. The values are overall a bit higher. We recognize however fragments of the shape pictured in Figure 4: the rise from $\lambda_\odot = 26^\circ\!.2$ onwards and the maximum night with the main maximum at $\lambda_\odot = 261^\circ\!.36$ are exactly what we found before in this report.

All averages above were obtained attributing an equal weight to each ZHR. The larger the correction factor, the less accurate the ZHR. An option of the *VMDB* is to introduce a weighing factor $1/C_{\rm tot}$ with $C_{\rm tot}$ being the total correction factor used to obtain the ZHR:

$$C_{\rm tot} = \frac{1}{C_1} + \frac{1}{C2} + \cdots + \frac{1}{C_m}$$
$$N = N_1 + N_2 + \cdots + N_m$$
$$\mathrm{ZHR}_i = C_i \times N_i \ (1 \le i \le m)$$
$$\mathrm{ZHR}_{\rm avg} = \frac{N}{C_{\rm tot}}$$

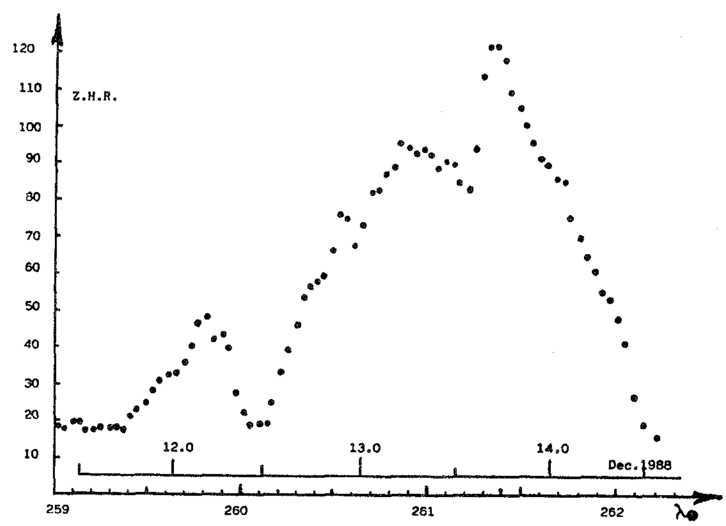

Figure 6 – The activity profile pictured in Figure 4, but recomputed with a weighted sliding mean over a 6 hour sampling period.

This option does not alter the shape of the activity profile a lot (compare Figure 4 with Figure 6). Experience with other showers already showed this before. As an experiment, the individual Japanese ZHRs were added to the *VMDB* ZHR file. This represents an additional data input of about 75% of the originally available data points. It is a good test to verify how strong our activity profile depends upon the observers characteristics. If the shape of the profile would differ significantly, some features would be very likely to be spurious. The result of the weighted sliding mean of 668 ZHRs, over a 6 hour sampling period advancing with a step length of 1 hour is shown in Figure 7.

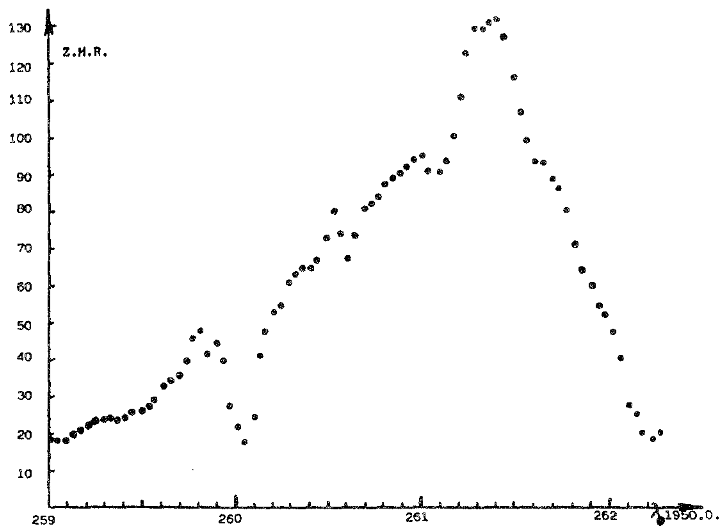

Figure 7 – Averaged Geminid ZHRs using a 6 hour period for American, Australian, European and Japanese observations.

Instead of disappearing, some features get more significant. The main shape of the profile remains intact. The high activity noticed at $\lambda_\odot = 259^\circ\!.9 \pm 0^\circ\!.1$ is seen only by few European and one American observer who all agree but who are not very numerous to give convincing evidence. This small peak with a considerable ZHR of 50, has never been reported before, but this is not a reason to deny it. This is the first single year global Geminid analysis. Previous attempts date back to 1985 [7], and 1980 [2] and involved mainly European and very few American data. No data were used to cover the Japanese-Australian observing window. We can only hope that future Geminid efforts will shed more light on this secondary Geminid-maximum. Seen from a theoretical point of view, we may remember the explanation D.W. Hughes and I.P. Williams [8] came up with to explain the main maximum. According to them, a filament of more densely packed meteoroids in the stream would be encountered now by the Earth at the outer edge of the stream. If the Earth starts to encounter a new filament, situated more in the center of the stream, it may show itself in a way like the mini-maximum. At this stage it is simply too early to think about this possibility as some confirmation must be obtained from future observing projects.

Another feature represented in all graphs of the maximum is the very broad maximum. The activity increase stops at $\lambda_\odot = 261^\circ$ when a small plateau effect is seen. Activity drops a bit at $\lambda_\odot = 261^\circ\!.1$ before rates go up to the main maximum peak at $\lambda_\odot = 261^\circ\!.38 \pm 0^\circ\!.08$.

J. Jones [9] suggested a double maximum or a plateau effect for the Geminid activity profile based on his theoretical model for the Geminid evolution. His model suggests that the Geminid cross section can be compared to a thick pipe of meteoroid dust, resulting in a twin-peaked activity. He considered radar data to be unsuitable to resolve short term activity variations. He found observational evidence in the visual work of one observer, Norman McLeod.

David Hughes [10] concluded he found a bifurcation in the Geminid activity, separated by 0.8 day (0.014 AU) in the 1980 analysis [2]. The radio results presented in [2] yield an activity profile similar to Figure 7 above, but a bit wider. The visual activity profile is too incomplete however (no Pacific observers) to allow direct comparison to Figure 7.

A bit more complete were the 1985 results [7]: then a broad maximum was recorded starting at $\lambda_\odot = 261^\circ\!.24$ ending at $\lambda_\odot = 261^\circ\!.76$. The highest rate was at $\lambda_\odot = 261^\circ\!.32$ (120) and a second best rate occurred at $\lambda_\odot = 261^\circ\!.72$. Peter Jenniskens [5] used mainly the same data and found $\lambda_\odot = 261^\circ\!.32 \pm 0^\circ\!.02$ as the main peak followed by a lower peak at $\lambda_\odot = 261^\circ\!.65 \pm 0^\circ\!.01$. He considered two Gaussian shaped curves to split the maximum profile into two superimposed curves. From the spatial separation of the two maxima he derived an age of 1600 years for the Geminids, assuming the Earth does not cross the center of the meteoroid pipe.

Reference [2] mentions $\lambda_\odot = 261\overset{\circ}{.}3 \pm 0\overset{\circ}{.}2$ as time of maximum activity, in good agreement with our conclusion. Porubcan et al, [11] found $\lambda_\odot = 261\overset{\circ}{.}0 \pm 0\overset{\circ}{.}2$ for the period 1944–1974, coinciding with the start of our main maximum. In 1974, Porubcan and Stohl [12] quoted the peak at $\lambda_\odot = 261\overset{\circ}{.}32$, our main peak. Contrary to 1980 and 1985, no peak rates come out the 1988 data at about $\lambda_\odot = 261\overset{\circ}{.}7$. Rates were still high at this time, but nevertheless already steeply declining. However, a filamentary structure, with superimposed belts of meteoroid dust may explain the activity profile as well. Whatever future computer models will tell us, the 1988 observations indicate the Geminid ZHR profile contains much information. Some features are not very well explained so far.

4. How important is the perception coefficient?

Table 1 – The observers' perception coefficients derived from the 1988 Perseid activity profile. The abbreviations can be found in [1].

Obs.	P	Nr.	σ	Obs.	P	Nr.	σ	Obs.	P	Nr.	σ
ARAKT	2.74	7	0.73	ARLRA	0.43	13	0.09	ATHJA	0.84	24	0.18
BENLA	1.15	9	0.31	BLAGU	0.53	59	0.16	BOAAN	0.51	18	0.15
BROPE				CAMPA	1.06	11	0.13	CANFR	1.46	12	0.31
CLAMA	0.73	31	0.21	CLEMA	0.93	42	0.19	COCLO	0.60	12	0.18
CORMA	0.66	72	0.23	D'ALU	0.93	18	0.24	DAVMA			
DELST	0.47	12	0.16	DIOMA	0.55	23	0.12	DRUJO			
ELTMA	1.07	30	0.26	ENGTO	1.63	18	0.42	FELKI	0.33	15	0.15
FUKUK	0.57	37	0.09	FUKUT	1.23	42	0.27	GAAKA	1.26	36	0.22
GIUMA	1.07	6	0.12	GLOMA	0.72	83	0.20	GORRO	0.53	18	0.10
GUIGU				HARNI	1.26	18	0.08	HASTA	0.17	6	0.01
HAVRO	0.56	24	0.09	HEELA	1.12	45	0.31	HINCR	0.73	6	0.05
ITODA	1.48	7	0.20	IZUKI	0.46	11	0.25	KAMTO	1.10	12	0.20
KAWHI	1.32	49	0.37	KAWJU	0.93	23	0.28	KAWNO	0.91	15	0.44
KIKOY	2.16	6	0.16	KNOAN	0.47	23	0.15	KOBMA	1.11	36	0.11
KOMAT				KOSIN	1.44	30	0.27	KOSRA	0.52	12	0.12
KUEWI	0.90	28	0.24	KUSRA	0.42	12	0.14	LATAL	1.24	17	0.32
LUNRO	0.77	107	0.22	MACAL	1.06	6	0.04	MAEKO	1.51	47	0.30
MAMKA	0.86	139	0.22	MARFR	0.64	27	0.30	MARPA	1.10	54	0.21
MARUT	1.97	31	0.36	MCBAL	0.94	29	0.22	MELFA	1.10	18	0.16
MIYAT	5.77	6	0.20	MIZHI	1.55	19	0.39	MOOJO	1.31	16	0.30
MORDI	0.32	15	0.13	MORSA	2.61	6	0.23	MUTNA	0.11	6	0.00
MUTON	0.76	43	0.27	NAGAT				NARUS	1.24	19	0.27
NASAL	0.30	6	0.03	NISSE	0.98	61	0.23	NOZEK	0.60	6	0.17
OKAM	2.27	31	0.69	PIEAL	1.20	12	0.13	PLAGE	0.71	80	0.20
RAFST	0.76	6	0.09	RENIN	0.72	12	0.21	RENJU	0.88	63	0.26
RIZMA	0.43	6	0.04	ROGPA	1.02	136	0.33	ROSLI	0.70	12	0.12
SAGTO	1.47	1	0.00	SAKKO	0.66	13	0.07	SATOH	0.80	25	0.23
SCAFR	1.88	6	0.18	SEIHO	0.21	6	0.06	SHIYA	1.74	11	0.34
SIKOY	2.06	25	0.19	SINDO	4.42	11	2.28	SIOTK	2.00	6	0.05
STIDA				STOEN	0.82	12	0.09	STOST	1.04	21	0.29
SUZUY	3.40	6	0.11	SWADA	1.17	6	0.08	TAIRI	0.95	23	0.33
TAKJU	1.62	31	0.49	TOMHI	1.07	17	0.23	TORIY	1.27	6	0.17
TREMI	0.43	12	0.02	TRIEM	0.79	12	0.31	TRIJO	1.34	59	0.42
UEDMA	1.41	38	0.39	UENTO	1.64	24	0.27	UYAYO	0.86	68	0.21
VILMI	1.62	24	0.19	VODRO				WALWI	1.17	12	0.32
WOOJE	1.38	99	0.43	WUNNI	1.12	7	0.19	YABYA	1.00	55	0.30
YASFU	1.19	19	0.29								

The two dips in Figures 2 and 4 at $\lambda_\odot = 260\overset{\circ}{.}1$ and $261\overset{\circ}{.}2$ are both in the observing interval of the same few observers. The separated Japanese ZHRs also show such a dip at $\lambda_\odot = 261\overset{\circ}{.}25$. The American observing window is covered by very few observers, which means that there is much chance for getting spurious features. When the Japanese and other data come together, the dip at $\lambda_\odot = 261\overset{\circ}{.}2$ becomes much less abundant; the dip in Japanese ZHRs disappears completely. This made the author suspicious that with too few observers at some hours, perception influences were responsible for some likely spurious details. Figure 6 can mislead someone to think about a twin maximum, if the numbers of ZHRs in the samples are neglected. Therefore the activity profile of Figure 7 was used to estimate the perception coefficients for the 109 observers.

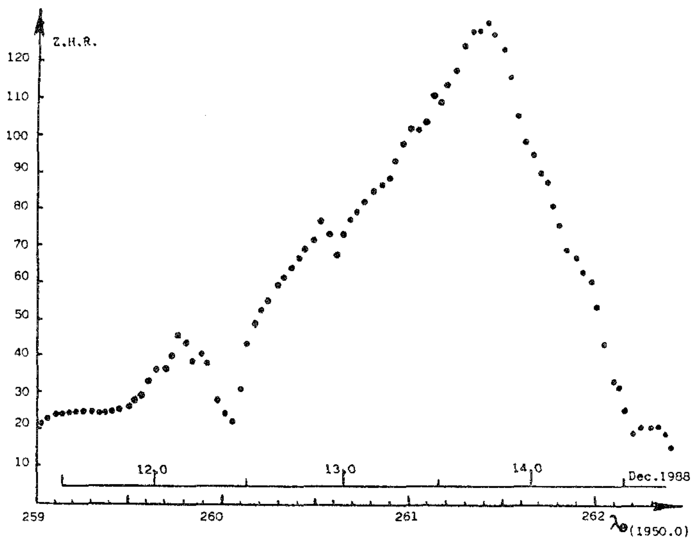

Figure 8 – Perception-corrected version of Figure 7.

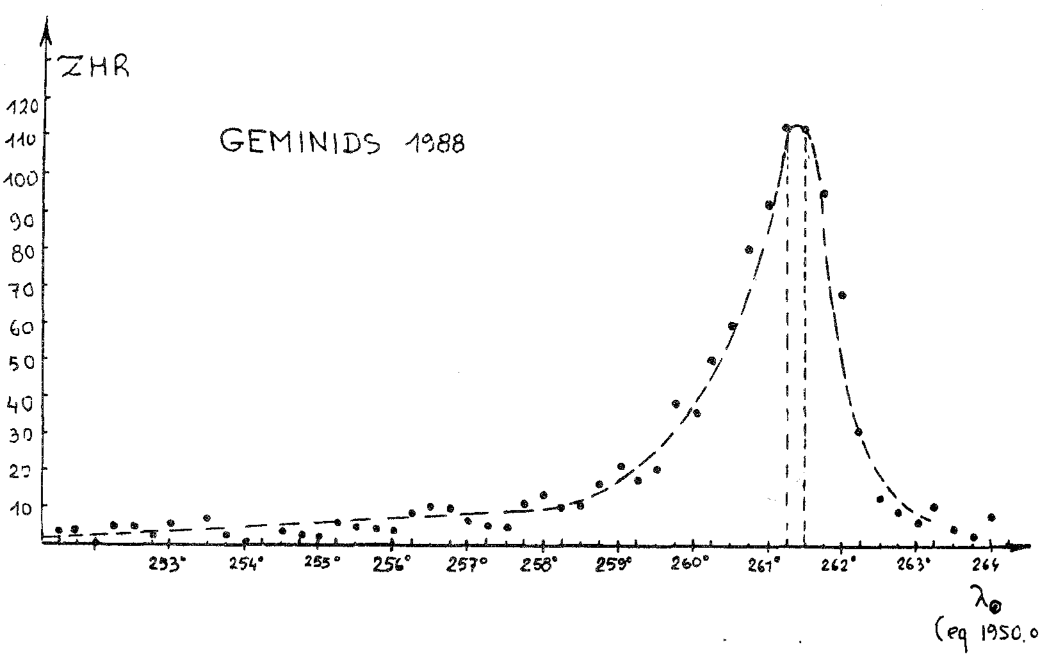

Figure 9 – Presentation of how the 1988 results would look like in the "old style".

The method developed in the *VMDB* to get perception coefficients from a meteor stream profile can be found in [13]. The resulting coefficients are given in the table below and are useful information for all the observers involved.

The 668 ZHRs were perception corrected and a weighted sliding mean over a 6 hour period was obtained again. This final curve is shown as Figure 8.

Only the dip at $\lambda_\odot = 260^\circ\!.1$ was not smoothed with the perception correction. Otherwise, the profile became amazingly smooth, showing very clearly the peak at $\lambda_\odot = 261^\circ\!.38 \pm 0^\circ\!.08$. This peak has occurred at December 14, $0^h \pm 2^h$ UT in 1989 over Europe. Unfortunately the Full Moon disturbed a lot. We would like to produce these activity profiles for past years' data, so that the variation in the shape of the curve can be compared from one year to another. Figure 9 shows an activity graph in the way the best results of past years were presented, before the *VMDB* was available. Just compare Figure 9 to Figure 8, to convince yourself it is worth while sending in all your data that may help us to make more graphs like Figure 8.

5. Magnitude distributions

An often reported phenomenon with the Geminids is that the solar longitude of shower peak activity varies with visual meteor magnitude [3]. All magnitude data were accumulated per date, limiting magnitude corrected r-values computed and results are presented in Table 3. For the conclusions we can be very short: we cannot confirm this from the 1988 data. The reason is that too few observers reported the Geminid and sporadic magnitude distribution per date. It must be emphasized again that the use of hourly rate data is limited if no magnitude distributions detailed per night, per observer, per shower and for the sporadics are given. So please make an effort and report all your data in a complete report format according to the *IMO* format.

Table 2 – Global magnitude distributions of the 1988 Geminids and the sporadic background.

Date	Sh	Lm	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7	Tot	$\overline{m}$
Dec 07	G	5.48	0	0	0	0	0	0	1	1	2	2	0	0	0	0	6	1.83
07	S	5.49	0	0	0	0	0	1	1	3	7	18	15	5	0	0	50	3.10
08	G	5.30	0	0	0	0	0	0	1	0	1	2	2	0	0	0	6	2.67
08	S	5.30	0	0	0	0	0	0	0	0	1	4	3	0	0	0	8	3.25
09	G	5.75	0	0	0	0	1	2	0	3	2	5	2	1	0	0	16	1.94
09	S	5.81	0	0	0	0	0	0	0	1	3	5	5	2	0	0	16	3.25
10	G	5.00	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	2.00
10	S	5.00	0	0	0	0	0	0	0	0.5	0.5	1.5	3.5	0	0	0	6	3.33
11	G	6.34	0	0	1	1	2	5	12	17	33	51.5	38.5	21	2	0	184	2.68
11	S	6.00	0	0	1	0	0	1	1	5	11.5	23	29	8.5	0	0	80	3.13
12	G	6.27	0	1	0	3	3	5	27	38	60.5	127	105.5	39	3	0	412	2.79
12	S	6.15	0	0	0	0	0	1	5	9	16	35.5	43	35.5	4	0	149	3.49
13	G	6.48	0	1	1	2	13.5	31.5	56	117.5	217	310.5	231	98	5	0	1084	2.63
13	G	6.14	0	0	0	0	1	0	0	5	8.5	36	44.5	20.5	1.5	0	117	3.57
14	G	6.01	3	0	2	7	23	54	83.5	134.5	204	306.5	232	92.5	7	0	1149	2.39
14	S	5.86	0	0	0.5	0.5	1	2	2	6	13.5	39	74	39	4.5	0	182	3.63
15	G	6.20	0	0	0	0	0	1	1	1.5	9.5	13	6.5	4.5	0	0	37	2.89
15	S	6.20	0	0	0	0	0	0	1	0	2	8.5	6.5	4	0	0	22	3.43
16	G	6.00	0	0	0	0	0	0	0	0	1	1	0	1	0	0	3	3.33
16	S	6.00	0	0	0	0	0	0	0	0	1	3	3	3	0	0	10	3.80
Tot	G	6.25	4	4	13	45.5	152	349.5	552.5	940.5	1532	1877	1369	636.5	91.5	0	7575	2.37
Tot	S	6.05	0	0	3.5	5	19.5	27.5	81.5	154	239.5	425.5	500	320	85.5	1.5	1863	3.19

Table 3 – Mean magnitudes, r-values and correlation coefficients for the 1988 Geminids and the sporadic background.

Date	Sporadics					Geminids				
	Tot	Lm	$\overline{m}_{corr}$	r	Corr.	Tot	Lm	$\overline{m}_{corr}$	r	Corr.
Dec 11	80	6.00	3.13	3.53	0.995	184	6.34	2.68	2.46	0.999
12	149	6.15	3.49	3.81	0.995	412	6.27	2.79	2.53	0.996
13	117	6.14	3.57	4.61	0.998	1084	6.48	2.63	2.69	0.997
14	182	5.86	3.63	3.08	0.975	1149	6.01	2.39	2.43	0.994
15	22	6.20	3.43	3.52	0.988	37	6.20	2.89	3.03	0.994
Tot	1863	6.05	3.19	2.97	0.996	7575	6.25	2.37	2.62	0.997

References

[1] P. Roggemans, "The Geminid Meteor Stream and 1983 TB", *WGN* 12:4, August 1984, pp. 114–130.

[2] G.H. Spalding, "The Geminid Meteor Stream in 1980", *JBAA* 92, 1981–82, pp. 227–233.

[3] G.H. Spalding, "The Geminid Meteor Stream", *JBAA* 93, 1982–83, p. 175.

[4] P. Roggemans, "The 1988 Leonid Meteor Stream", *WGN* 17:3, June 1989, pp. 100–103.

[5] P. Jenniskens, "De struktuur van het Geminidenmaximum", *Radiant* 8, 1986, pp.58–59 (in Dutch).

[6] H. Tomioka, "Geminids", *NMS Astronomical Circular* 559, February 1989, pp. 3–7 (in Japanese).

[7] P. Roggemans, "On the Geminid Meteor Stream in 1985", *WGN* 14:2, April 1986, pp. 48–62.

[8] K. Fox, I.P. Williams, D.W. Hughes, "The Rate profile of the Geminid meteor shower", *Mon. Not. R. Astr. Soc.* 205, 1983, pp. 1155–1169.

[9] J. Jones, "The Structure of the Geminid Meteor Stream I — The Effect of Planetary Perturbations", *Mon. Not. R. Astr. Soc.* 217, 1985, pp. 523–532.

[10] D.W. Hughes, "Hollow meteoroid streams", *Nature* 319, February 1986, p. 718.

[11] V. Porubčan, M. Kresakova, J. Stohl, "Geminid Meteor Shower, activity and magnitude distribution", *Contr. Astr. Obs. Skalnate Pleso* 9, 1980, pp. 125–143.

[12] V. Porubčan, J. Stohl, "Observations of the Geminids 1974 at the Skalnate Pleso Observatory", *Contr. Astr. Obs. Skalnate Pleso* 8, 1979, pp. 71–79.

[13] P. Roggemans, "The 1988 Perseid Meteor Stream and the Perception Coefficients", *WGN* 17:5, 1989, pp. 189–193.

The 1988 Geminids: a Postscript

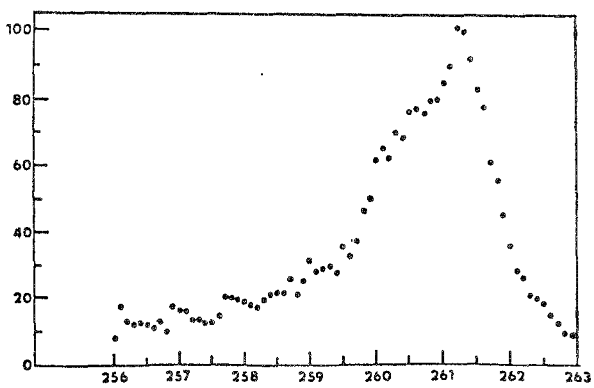

Figure 1 — Activity profile of the 1988 Geminids obtained from radio observations at Ondřejov with 1 s $< T_A <$ 8.05 s.

After the article above was typed, a paper appeared in the Bulletin of the Astronomical Institute of Czechoslovakia [1] describing the activity profile of the Geminids as obtained from radio observations at Ondřejov, Czechoslovakia, and Ottawa, Canada. They found that the position of the peak in the stream profiles shifts by −0°1 per meteor magnitude and that the widths of the stream profiles and the degree of the asymmetry also depend on the particle size. The reason why we mention this article, however, is that the professional activity profiles presented therein are strikingly similar to the ones shown by Paul Roggemans in the above report. Just, as an example, we reproduced one of the curves in [1]; we invite the reader to compare it to e.g. Figure 8 in the above report (Ed.)

Reference

[1] M. Šimek, B.A. McIntosh, "Geminid Meteor Stream: Activity as a Function of Particle Size", *Bull. Astron. Inst. Czechosl.* 40:5, 1989, pp. 288–298.

On the Bimodality of the Geminid Meteor Shower

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The problem of double maxima in meteor showers of cometary origin is discussed. The simulation method is described. The simulation results and observational data for the Geminid meteor stream are presented.

The last few years were devoted by the author of the present paper to the study of the Geminid meteor stream origin and evolution. The Monte Carlo simulation method is a very convenient and effective one for this purpose. Briefly the simulation process can be described as follows (see [1] for details).

The ejections of meteoroids are simulated from an assumed parent body in a definite way. The schemes of the ejection can be varied. For example, it can be a cometary type of ejection, when particles are ejected from the solar hemisphere of a nucleus along the entire cometary orbit with increasing the ejection velocity and rate of ejected dust towards perihelion. Or it can be an eruption type of ejection, when the ejection takes place in a single point of the parent orbit. Then the evolution of each individual particle orbit is followed by using a special kind of approximating polynomials. In such a way, we can obtain the spatial distribution of a modeled stream, the flux density distribution in some cross-sections, dispersion, etc., at different stages of the evolution.

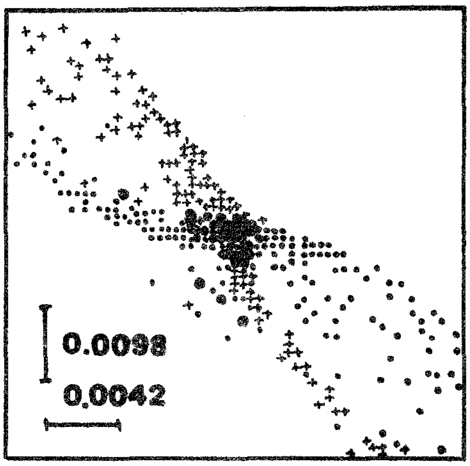

Figure 1 — The central fragment of the Geminid model cross-section. The cells intersected by particles generated in pre-perihelion ejections are indicated by crosses; those by particles from post-perihelion ejections by small dots; and those by both kinds of particles by big dots. Scale in AU.

One of the simulation results was quite unexpected, namely the bimodality of the Geminids' rate profile. The bimodality takes place only when a cometary type of ejection model is used. When we use the eruption type model, the activity profile has only one maximum.

It turned out that the model stream was stratified into two "jets". The Earth in its motion intersects the jets one by one causing the bimodality of the shower. The reason for the stratification is the separation of the orbits originating from the pre- and post-perihelion ejections (see Figure 1) in the process of evolution. The interval between the first and second maximum depends on the meteoroid mass and on the place where the Earth intersects the stream too, because the two jets are not parallel. In the considered model, the interval between maxima is 1°3 in solar longitude for a meteoroid mass of 3×10^{-3} g, and 1°8 for a mass of 3×10^{-4} g. The first (or main) maximum is recorded earlier for smaller particles and the second maximum, inversely, is recorded earlier for larger particles.

The criterion for the simulation correctness is the agreement with observational data. We have some data supporting the hypothesis of the Geminids' bimodality.

In Table 1, the positions of the maxima are presented according to [2,3], where the flux density distribution according to the solar longitude is considered. We can see that the results of [2,3] are qualitatively consistent with the results of the simulation.

M. Šimek [4] presents the mean activity profiles for some mass intervals of meteoroids. In his group N1, where the mean radio magnitude was 3.1 ($m = 0.0137$ g according to the mass scale in [5]), we can see the secondary maximum shifted by 0°5 from the main maximum. Visual observations of the Geminids from the period 1970–79 [6, Figure 3] show the secondary maximum shifted by 0°8 from the main one. The existence of the secondary maximum in these two cases is problematical; maybe we just deal with some fluctuations. The visual observations presented by P. Jenniskens [7, Figure 2], however, clearly show a double maximum with first and second maximum separated by 0°3 in solar longtitude.

Table 1 – Positions of the first and secondary maximum of the Geminid meteor shower according to [2] ([3]).

m	$\lambda^1_\odot$	$\lambda^1_\odot$	$\Delta\lambda$
3×10^{-3} g	261°25		
	(261°5)		
3×10^{-4} g	260°50	262°25	1°75
	(260°0)	(263°0)	(3°0)
3×10^{-5} g	259°85	262°50	2°65
	(258°5)	(263°9)	(5°4)
3×10^{-6} g	256°60	262°75	6°15
	(258°0)	(264°0)	(6°0)

Concluding this brief discussion, we can note that we now have some arguments in favor of the Geminids' bimodality, but we certainly need more observational data.

The simulation was performed for the Geminid meteor stream, but we have all reasons to believe that the formation of many streams having similar ejection mechanisms proceeds analogously. Therefore, some meteor streams of cometary origin could have two maxima. And indeed, a double maximum for the Perseid meteor stream was reported recently by P. Roggemans [8].

References

[1] G.O. Ryabova, "The effect of secular perturbations and the Poynting-Robertson effect on the structure of the Geminid meteor stream", *Astronomicheskij Vestnik* 23:3, 1989, pp. 254–264 (in Russian).

[2] G.V. Andreev, A.E. Epishova, O.A. Mugruzina, L.N. Rubtsov, "On the structure of the Geminid meteor stream on the basis of the long term radio observations in Dushanbe", *Astronomiya i geodeziya* 13, 1985, pp. 37–49 (in Russian).

[3] O.I. Belkovich, N.I. Sulejmanov, V.S. Tokhtas'ev, "The Geminid shower from radar, photographic and visual observations", *Meteor matter in the interplanetary space*, 1982, pp. 88–101 (in Russian).

[4] M. Šimek, "Geminid meteor stream: mean activity profiles from radar observations", *Techn. Rep. Czechosl. Acad. of Sci., Astron. Inst.* 68, 1988.

[5] D.W. Hughes, "Meteors", *Cosmic Dust*, Wiley, Chichester, 1978, pp. 123–185.

[6] G.H. Spalding, "The Geminid meteor stream in 1980", *J. BAA* 92:5, 1982, pp. 227–233.

[7] P. Jenniskens, "On the shapes of ZHR profiles", *Proc. of the IMW 1988*, pp. 43–48.

[8] P. Roggemans, "The Perseid Meteor Stream in 1988: a Double Maximum!", *WGN* 17:4, August 1989, pp. 127–137.

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Fireball streams

A.K. Terentjeva, Astr. Council USSR Acad. of Sciences

A Complex of large meteor bodies responsible for ordinary fireballs and meteorites is investigated. 78 fireball streams have been discovered. Orbital parameters of these streams are given. Some conclusions on the relationship between meteor bodies and other bodies in the solar system are made.

The present paper has the following purpose: the determination on the basis of the up-to-date photographic data of the distribution of large size meteoric matter, i.e. fireballs, the revelation of streams (if any) of these bodies, and their association with meteor streams and other minor bodies in the solar system like comets, asteroids and meteorites.

We analyzed the photgraphic data of 554 fireballs, provided by the fireball networks in the USA and Canada [1,2] during 1963–1984. The analysis of the photographic data takes into account not only the degree of coincidence of the radiant coordinates, the shower velocity, the data of its visibility and orbital elements. but also the radiation area, its shape, the magnitude and direction of the diurnal motion of the radiant, and also some other peculiar characteristics of the shower, the position of the radiant on the celestial sphere as well as peculiarities of the stream orbit and a type of possible planetary perturbations. Minor streams and associations, of which several hundreds are known by now, vary much more than scanty large and compact streams. Both kind of streams should not be reduced to a "common denominator" (by means of existing criteria), if we want to understand all the variety of meteor complexes.

The result obtained can be summarized as follows:

1. 78 fireball streams which include 375 fireballs (of the total of 554) have been detected. Thus among large meteor bodies the organized matter constitutes 68%. Among ordinary photographic meteors this fraction is smaller: 56% according to Terentjeva [3] or 43% according to Lindblad [4]. Among fainter meteors (approximately up to +7), this fraction is only 28% [5].

   The table contains for each of the 78 fireball streams the abbreviated designation, the period of the activity, the mean value of the coordinates α and δ for the corrected geocentric radiant, the extra-atmospheric velocity V_∞ and the orbital elements. Two fireball streams (nrs. 56 and 76) are the Perseids and the Geminids respectively.

Table 1 – Orbital parameters of 78 fireball streams (Eq. 1950.0). Distances are expresses in AU, velocities in km/s, and angles in degrees.

Nr	Stream	Date	α	δ	V_∞	q	a	e	i	ω	Ω
1	μ-Ori	I 1–II 4	88	+12	16.4	0.854	1.866	0.524	4.1	51.7	112.5
2	θ-And	I 3–11	20	+40	13.6	0.980	1.904	0.484	6.2	188.6	286.3
3	ξ_2-Cet	I 4–9	37	+08	13.6	0.978	1.986	0.508	1.2	7.8	105.6
4	γ-Del	I 4–16	311	+18	17.9	0.896	2.414	0.623	12.6	140.0	289.0
5	μ-Per	I 4–19	69	+49	16.4	0.923	2.341	0.603	8.7	213.4	292.3
6	α-Cnc (a)	I 10–II 26	131	+12	26.8	0.475	2.114	0.761	6.3	101.9	125.0
	α-Cnc (b)		144	+18	20.8	0.502	1.081	0.535	10.1	294.0	307.8
	α-Cnc (c)		137	+18	20.7	0.729	2.182	0.664	4.3	69.0	145.7
7	ε-Col-θ-CMa (a)	I 14–30	80	−36	20.0	0.952	3.008	0.684	21.8	22.9	117.7
	ε-Col-θ-CMa (b)		102	−09	19.8	0.846	2.430	0.646	14.3	50.2	124.0
8	α-Gem (N)	I 16–II 9	120	+27	21.1	0.658	1.822	0.632	3.3	262.1	301.8
	α-Gem (S)		118	+12	18.0	0.799	1.998	0.584	3.8	61.3	135.3
9	η-Per	I 21–II 14	32	+58	14.0	0.984	1.883	0.477	9.2	185.6	312.7
10	ψ-Peg	I 25–28	358	+30	14.3	0.976	2.177	0.552	6.5	167.2	305.9
11	Lyn I	II 4–27	114	+52	16.0	0.938	2.195	0.569	9.4	209.2	329.2
12	β-φ-Leo	II 6–III 23	159	+07	20.5	0.663	1.737	0.613	3.2	262.8	341.7
13	α-Hyd	II 12–24	138	−04	20.9	0.719	1.975	0.625	10.3	73.0	149.3

Table 1 – continued.

Nr	Stream	Date	α	δ	V_∞	q	a	e	i	ω	Ω
14	ν-Vir (N)	II 14–III 6	168	+11	29.8	0.394	2.324	0.822	5.6	289.6	335.2
	ν-Vir (Q)		170	+04	30.6	0.384	2.578	0.850	0.3	109.1	160.4
	ν-Vir (S)		161	−02	29.7	0.498	4.312	0.884	9.1	93.4	160.8
15	β-Cep	III 3–31	318	+72	20.6	0.978	2.248	0.556	26.5	164.7	356.1
16	Hyd	III 4–15	131	−12	17.3	0.904	2.313	0.606	10.5	40.3	167.3
17	π-Cas	III 4–16	4	+48	17.6	0.934	2.567	0.636	14.3	148.8	349.0
18	ν-Hyd	III 12–IV 8	158	−11	22.3	0.718	2.521	0.714	9.6	70.8	183.9
19	η-Vir (N)	III 13–IV 11	210	−02	33.2	0.314	2.497	0.872	12.6	298.4	15.2
	η-Vir (Q)		187	−05	30.3	0.359	2.197	0.828	3.4	114.4	177.3
	η-Vir (S)		178	−11	32.5	0.397	4.126	0.904	12.3	105.4	174.5
20	χ-Vir	III 27–IV 28	184	−11	19.1	0.770	2.092	0.620	4.0	66.9	200.7
21	65-Vir	III 31–IV 6	192	−02	24.0	0.605	2.278	0.732	2.2	266.3	13.8
22	ι-Leo (N)	IV 9–18	180	+18	16.2	0.908	2.250	0.596	5.2	221.7	23.6
	ι-Leo (S)		167	−22	16.1	0.912	2.006	0.546	8.1	42.3	206.0
23	86-Vir	IV 9–24	218	−16	34.1	0.257	2.188	0.884	8.8	306.1	23.8
24	β-Lib	IV 11	205	−16	29.2	0.426	2.374	0.818	4.6	106.0	201.0
25	Lyn II	IV 15–18	116	+53	14.0	1.002	2.290	0.562	6.8	174.6	26.4
26	η-Uma	IV 25–V 25	203	+51	16.6	0.995	2.404	0.578	15.6	194.0	53.3
27	φ-Ser	V 1–3	226	+02	21.4	0.648	1.620	0.598	10.8	267.4	41.4
28	Lib (N)	V 1–4	228	−07	29.1	0.457	2.617	0.826	10.2	282.0	40.6
	Lib (Q)		227	−19	27.0	0.482	2.157	0.776	1.3	101.4	223.6
	Lib (S)		217	−31	27.9	0.547	3.232	0.831	13.3	90.5	222.7
29	ψ-Vir	V 3–31	191	−07	14.2	0.949	1.889	0.495	2.2	33.4	235.7
30	ι-Cas	V 9–VI 1	42	+69	22.1	0.860	2.265	0.618	24.6	128.1	56.0
31	α-Sco	V 12–15	243	−28	32.6	0.324	2.469	0.868	8.9	117.7	232.4
32	Lib-Cen	V 12–18	213	−22	19.6	0.790	2.472	0.680	3.8	62.5	233.2
33	μ-Sgr	VI 2–28	270	−20	25.9	0.544	2.415	0.768	3.2	274.8	86.4
34	k-Boo	VI 5–7	229	+50	17.0	1.004	2.140	0.530	18.4	194.2	75.1
35	ε-Lib	VI 20–VII 6	233	−10	17.0	0.944	4.170	0.763	4.9	32.8	276.2
36	ε-UMa	VII 1–15	192	+62	18.9	0.980	2.994	0.659	20.0	156.3	105.1
37	μ-Ser	VII 3–31	232	−04	14.1	0.992	2.447	0.594	3.3	197.3	114.3
38	η-Ser	VII 6–X 19	277	−04	14.9	0.916	1.792	0.486	5.2	209.5	150.8
39	β-Cap	VII 7–23	302	−16	25.1	0.491	1.726	0.708	3.9	284.5	112.2
40	τ-Sgr	VII 10–18	286	−28	19.5	0.722	1.814	0.594	2.8	77.7	289.9
41	Per	VII 30–VIII 12	38	+56	60.3	0.963	25.366	0.975	112.8	154.5	134.9
42	φ-β-Aqr (a)	VIII 4–IX 25	344	−04	26.6	0.508	2.294	0.774	6.0	278.2	159.4
	φ-β-Aqr (b)		314	−02	27.6	0.529	2.678	0.802	13.0	274.2	131.6
43	δ-Cap	VIII 13–31	324	−14	22.0	0.672	2.138	0.685	1.8	259.8	146.6
44	Equ-Gru (N)	VIII 18–X 22	319	+09	18.3	0.868	2.629	0.659	9.3	228.5	169.2
	Equ-Gru (Q)		321	−13	16.3	0.898	2.294	0.607	2.8	39.7	355.5
	Equ-Gru (S)		342	−52	18.0	0.907	2.205	0.589	14.9	43.1	344.8
45	ν-Dra	IX 1–22	260	+54	21.5	1.001	2.679	0.624	28.3	174.5	170.3
46	ξ-Per	IX 9–17	54	+36	68.0	0.764	34.087	1.036	149.5	238.0	169.4
47	δ-Psc (N)	IX 12–X 3	6	+05	27.8	0.446	1.976	0.755	2.7	285.8	179.6
	δ-Psc (S)		4	−03	27.9	0.436	1.984	0.781	4.6	107.0	354.8
48	γ-Sgr	IX 13	270	−31	12.8	1.003	2.008	0.452	1.0	8.0	350.1
49	Peg-Cep (a)	IX 21–XI 23	338	+31	21.2	0.828	2.585	0.680	17.8	234.4	189.6
	Peg-Cep (b)		322	+44	22.6	0.904	3.428	0.736	25.0	218.1	190.0
	Peg-Cep (c)		334	+57	19.4	0.950	2.352	0.594	22.0	204.6	232.8
50	τ-Cet	IX 28–XI 26	18	−19	20.4	0.791	2.442	0.667	11.6	58.4	27.4
51	Lyr-Dra (a)	X 3–27	287	+40	17.0	0.994	2.322	0.567	17.8	184.5	198.6
	Lyr-Dra (b)		267	+55	20.7	0.992	2.120	0.532	27.6	171.4	204.6
52	α-Psc (N)	X 8–26	20	+11	25.8	0.479	1.780	0.782	1.6	283.8	196.4
	α-Psc (S)		33	+01	28.5	0.482	2.540	0.810	11.2	98.7	25.7
53	α-Cap	X 10–24	315	−14	15.3	0.987	4.264	0.768	0.8	190.8	203.1
54	γ-Psc	X 10–XI 25	347	±00	15.3	0.945	2.478	0.617	2.7	200.0	224.9
55	α-And	X 12–18	2	+26	21.8	0.738	2.441	0.688	12.4	248.6	201.2
56	o-χ-Dra (a)	X 12–27	283	+57	22.4	0.994	2.855	0.649	29.8	183.8	201.9
	o-χ-Dra (b)		277	+76	31.2	0.984	2.851	0.643	48.7	191.1	207.3
57	μ-Cet	X 14–XI 9	41	+10	31.8	0.381	2.883	0.892	6.6	108.8	32.3
58	π-Leo	X 25–XI 6	146	+08	12.6	0.510	0.756	0.324	4.0	189.0	37.4

Table 1 – continued.

Nr	Stream	Date	α	δ	V_∞	q	a	e	i	ω	Ω
59	τ-Ari	X 25–XI 11	52	+18	31.2	0.334	2.168	0.841	5.2	117.1	41.5
60	ε-Psc	X 26–XI 27	17	+09	17.5	0.871	2.866	0.668	1.4	224.9	229.1
61	κ-Dra	X 27–XI 10	192	+75	41.6	0.984	2.886	0.656	70.6	183.0	220.1
62	ψ_1-Aur	X 31–XI 3	93	+50	57.8	0.439	6.634	0.968	113.0	277.8	218.6
63	φ-And	XI 12–22	17	+46	18.0	0.854	1.824	0.522	13.8	232.4	234.1
64	Cam-Lep (N)	XI 12–XII 8	115	+70	14.6	0.566	0.794	0.287	16.1	337.0	228.9
	Cam-Lep (S)		91	−14	14.8	0.658	0.898	0.266	12.7	127.8	66.4
65	ω-Tau	XI 13–29	58	+20	25.1	0.557	2.454	0.750	3.8	91.3	59.9
66	ζ-Leo	XI 15–20	153	+22	70.0	0.981	16.210	0.820	162.6	172.5	235.3
67	μ-Ari (a)	XI 17–29	38	+21	19.8	0.794	2.608	0.694	5.3	238.2	240.6
	μ-Ari (b)		44	+15	14.6	0.834	1.294	0.350	0.4	246.4	239.9
68	ε-Eri	XI 18–28	52	−07	15.8	0.825	1.380	0.398	8.4	65.6	60.1
69	υ-Tau	XI 21–29	67	+22	29.5	0.418	2.443	0.828	2.9	286.0	241.8
70	δ-Ari (N)	XI 22–XII 21	53	+29	18.4	0.766	1.826	0.560	4.2	247.3	251.1
	δ-Ari (Q)		55	+18	19.4	0.786	2.440	0.671	1.2	59.7	75.0
	δ-Ari (S)		61	+07	18.6	0.788	1.982	0.591	5.8	62.8	75.4
71	Hya-Cnc	XI 30–XII 7	121	+04	59.6	0.253	113.8	0.999	127.9	119.3	71.8
72	ζ-Tau	XII 1–27	82	+23	26.1	0.523	2.185	0.756	4.0	275.0	261.0
73	ν-Cet	XII 9–14	39	+05	15.6	0.930	2.385	0.608	3.0	31.3	79.5
74	α-Tau	XII 11–22	71	+14	20.0	0.743	2.125	0.636	4.4	68.2	83.4
75	Gem (N)	XII 14–22	113	+32	35.8	0.175	1.592	0.889	24.4	319.1	263.8
	Gem (S)		113	+14	41.6	0.121	3.464	0.965	22.3	141.9	88.3
76	γ-Tri	XII 15–I 13	40	+32	15.4	0.932	2.292	0.582	4.7	209.3	272.3
77	α-Aur	XII 19–31	85	+42	22.5	0.694	2.365	0.700	11.2	253.6	274.0
78	Cam	XII 26–29	90	+62	22.8	0.760	2.096	0.636	21.8	245.4	275.8

2. In 14% of all cases we have detected N-S or N-Q-S branches. This means that among fireball streams the phenomenon of branching occurs twice as frequent as compared to minor meteor streams. In some fireball streams we have found two or three groups of orbits which are not branches in the sense above, but suggest the presence of similar features and are thus interrelated. Sometimes we deal with streams of a more complicated structure which are rather a system of separate minor streams than one stream.
3. As for minor meteor showers, ecliptical and nearly ecliptical fireball showers have as a rule a large area of radiation, probably larger than that of the ordinary meteor showers. Similarly to the latter showers, the area of radiation of some fireball showers has the shape of a strongly elongated ellipse with the center on the ecliptic and the big axis perpendicular to it.
4. Analysis of the Geminid fireballs shows that the Southern S branch of the Geminids does really exist (if we call the known stream the northern N branch). We could show this using the observations by Kresáková [6]. ([7])
5. The comparison of the detected fireball showers with minor meteor showers of the author's catalogue [3] and with the populations of large meteor bodies producing meteorites [8,9] has shown that 57% of the fireball streams are associated with meteor showers, and that 51% contain bodies forming meteorites. Some of the streams only consist of meteor bodies producing meteorites and do not show the presence of smaller meteor bodies.
6. The investigation of the connection between the population of bodies that produce fireballs and other minor bodies in the solar system using statistics of the Tisserand's constant (for Jupiter as perturbing planet) has shown that 60% of ordinary fireballs can be associated with comets and the rest, 40%, with asteroids. Among the fireball population of bodies that produce meteorites, more than 80% can be associated with the asteroids of the Amor group, 2% with asteroids of the Aten group, and less than 15% with asteroids of the Apollo group. But about 8% of the bodies producing meteorites as well as 15% of the asteroids of

the Amor group could have a genetic connection with comets of the Jupiter group. Thus we may expect that about half (or more than half) of the fireball streams which we have found, must have a genetic connection with comets and meteor streams of cometary origin, and the other part with asteroids and meteor streams of asteroidal origin. It might be possible there exist families of bodies whose members can be representatives of different classes of minor bodies: meteor streams, comets, ordinary fireballs, asteroids (mainly of the Amor type), large meteor bodies, and, more rarely, meteorites *or* meteor streams, asteroids of the Aten, Apollo or Amor type, ordinary fireballs, and large bodies, including those that produce meteorites.

References

[1] I. Halliday, A.A. Griffin, A.T. Blackwell, "MORP network fireball data (1971–1984)", *IAU Meteor Data Center*, Lund, Sweden.

[2] R.E. McCrosky, C.Y. Shao, A. Posen, "Prairie network fireball data (1963–1975)", *IAU Meteor Data Center*, Lund, Sweden.

[3] A.K. Terentjeva, *Rezult. Issled. MGP., Issled. Meteorov* 1, 1966, pp. 62–132.

[4] B.A. Lindblad, *Smithson. Contrib. Astroph.* 12, 1971, pp. 1–24.

[5] B.L Kashcheyev, V.N. Lebedinets, M.F. Lagutin, "Meteoric phenomena in the Earth's atmosphere", S.M. Poloskov Ed., Moscow, 1967 (in Russian).

[6] M. Kresáková, *Bull. Atron. Inst. Czech.* 25, 1974, pp. 20–33.

[7] A.K. Terentjeva, I.V. Galibina, *Astron. Tsirk.* 1256, 1983, pp. 5–7.

[8] I. Halliday, A.A. Griffin, A.T. Blackwell, *Highlights of astronomy* 6, R.M. West, Ed., 1983, pp. 399–404.

[9] A.K. Terentjeva, *Pis'ma Astron. Zh.* 3, 1989, pp. 258–269.

An International Tunguska Program

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The present paper describes an international program of expeditionary field work in the region of the Tunguska meteorite fall for the summer of 1990 and 1991.

The projected work in the region of the fall of the Tunguska meteorite like that in the previous years will consist of three parts and will develop in three principal directions:

1. continuation of investigation in the fields of physics of the Tunguska explosion;
2. search for the substance of the Tunguska cosmic body; and
3. investigation of biological aftereffects of the Tunguska catastrophe.

Besides, in connection with the appearance in press reports on deviations from normal course of time (A.V. Zolotov, 1987) allegedly taking place in the region of the Tunguska explosion epicenter, a corresponding check-up of the indicated data should be carried out.

1. Investigating the physics of the Tunguska explosion

Field investigations directed at marking the borders of the fire of the year 1908 for the purpose of determining the zone of initial flaring up more accurately will be continued. Investigations on the zonality of the forest fire of 1908 for the purpose of obtaining information on regularities

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and mechanisms of spreading the fire squall should be carried out. Special attention will be paid to the construction of a map of precatastrophic forest fires which could have exercised a serious influence on the stability of large tracts of forest against the blast and consequently on forming the outlines of the region of uprooting of the forest, caused by the Tunguska explosion.

2. Search for the substance of the Tunguska meteorite

This includes the following directions:

2.1. Defining the borders of the iridium anomaly which was formed in the first ten year period of the 20th century in the region of the catastrophe. With this purpose in mind, it is planned to select ten stratified columns of peat at different distances from the epicenter of the explosion with subsequent layer by layer determination of the contents of iridium, platinum, ruthenium, palladium, and rhodium.

2.2. In case the expedition has an international character, it is necessary to plan a selection of analogous columns of peat in Northern Canada as well as taking drill cores from stratified ice on glaciers of Greenland and Antarctica, with the purpose of analyzing them on platinoids. Carrying out investigations of that kind is necessary in connection with two points: firstly, in connection with Ganapati's reports (1985) concerning the presence of the iridium anomaly of 1908 in Antarctica, and, secondly, in connection with the publication of the data of G.A. Nikolsky et al. (1988), on the destruction in the Earth's atmosphere of one more large meteorite supposedly of iron-nickel composition in May 1908. If the iridium anomaly of 1908 is indeed connected with the fall of the Tunguska meteorite, then there must be a gradient in the anomaly from the region of the catastrophe (the basin of the Padkamennaya Tunguska) towards the periphery. If, however, the iridium anomaly was caused by the Aleutian bolid of May, 1908, the maximum anomaly must be found in Canada and Alaska. The same is true if the anomaly is not of a cosmic origin (which we do not exclude) but is caused by the activity of the volcanoes Katmai and Kzudach in 1907–1912.

2.3. Determining the outlines of the isotope anomaly in lead, carbon and hydrogen in peats of the Tunguska region, described by V.M. Kolesnikov. For this purpose of 20-30 columns of sphagnum peats will be selected. Similar peat samples have to be selected and analyzed from the control regions of the Western and Eastern hemispheres, especially in the regions rich in natural gas and oil, in order to exclude confusion with anomalies connected with migration in biosphere of "dead" hydrocarbons.

2.4. Search of finely dispersed components of the Tunguska meteorite in silts and other bottom depositions of bogs and lakes of the region of the catastrophe. The search must include the selection of stratified silts and their analysis on the content of nickel, cobalt, platinoids and other markers of cosmogenic aerosols.

2.5. Carrying out echo ranging of the bottom of the Southern bog above which the explosion of the Tunguska meteorite took place, with the purpose of revealing possible local disturbances of its bottom relief (search of the impact sinks connected with the fall of sufficiently large parts of the meteorite). To this end, a rather portable echo ranging equipment not heavier than 15–20 kg with self-contained power supply must be designed, fit for use in field conditions on a boggy place (work on a floating mat of a mire).

3. Investigation of the biological aftereffects

This includes the following directions:

3.1. A search in the region of the epicenter for mutations in the most widely-disturbed species of plants, determining their frequency of occurrence and mechanism of origin. The work must be carried out first and foremost within the region of increased mutations of pine trees in the epicenter zone, described by V.A. Dragavtsev et al. (1976–1980).

3.2. Looking for analogous effects in micro-organisms and other biological species ecologically bound to the region of the catastrophe.

4. Other investigations

Besides field work and laboratory investigation of materials requiring modern highly sensitive equipment (devices necessary for mass-spectrography, laser spectrography, and neutron activation), it is advisable to include in the program of the international permanently functioning expedition on investigating the Tunguska meteorite:

- Finding scattered information referring to geophysical anomalies during the summer of 1908 in various parts of the terrestrial globe. This information first of all deals with "light nights" and "particolored dawns", as well as with falls of meteorites and flights of bodies. This material did not undergo a systematic search. In the USSR, provincial newspapers of Europe and, more so, of the Western Hemisphere, India and Africa, are absent.
- Finding and analyzing other archival materials concerning the year 1908 and containing, possibly, essential information on geophysical events of the Summer of 1908. Rather expedient is, in particular, a search and an analysis of archival materials of Sharco and Shackleton's expeditions which took place at that time near the coast of Antarctica.
- Checking up the information on the Brazilian counterpart of the Tunguska meteorite whose fall, according to some information, took place in 1931 in the upper reaches of the Amazon.[1] For this purpose, it would be desirable to carry out a corresponding analysis of periodicals edited in Brazil in 1931, reports of missionary service, which are the source of this information, accounts of meteorological and geophysical observatories and stations functioning at that period in Brazil.
- Special analysis of periodicals from Canada and Alaska of May, 1908 with the purpose of checking up the story about the destruction of a large bolid in the region of Aleutian Islands around May 17.

The Brazilian Twin of the Tunguska Meteorite: Myth or Reality?

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According to some sources, an impact similar to the Tunguska event of 1908 has taken place in 1931 in the upper Amazon region of Brazil. This possibility is discussed.

The questions about the nature of the Tunguska meteorite are not answered up to now. Any progress in this field is problematic since the Tunguska event is unique. Therefore it is impossible to examine it using methods of comparison. Comparison of the Tunguska explosion with explosions and destructions caused by other fireballs or meteorites, such as the Revelstoke meteorite, is unreliable, since the energy of the Tunguska event (10^{18}–10^{19} J) exceeds the other ones by several orders of magnitude. Consequently, comparison would be incorrect.

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[1] *See the following article in this issue of WGN (Ed.)*

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In connection with this situation we would like to draw attention of the international astronomical public to the following. In 1931 the famous Soviet meteorite-scientist L.A. Kulik, who was the first researcher to examine the Tunguska meteorite, published a note entitled "The Brazilian twin of the Tunguska Meteorite" [1] in *Priroda i Ljudi* (which is Russian for "Nature and Men"), a popular scientific journal. The article included information originating from catholic missionaries published in some European newspapers (for example, the *Dayly Herald* of 6 March 1931) concerning a remarkable event of cosmic nature occurring at the upper Amazon region in Brazil.

These data led to the conclusion that in the early 1930ies an event of cosmic origin occurred at the upper Amazon River which was comparable with the Tunguska catastrophe of 1908 to a certain extent. One should assume a similar explosion and therefore also a similar forest devastation. Unfortunately, there was no check-up in due time, and forest destructions were not verified until today. Attempts of the Commission for Meteorites and Cosmic Dust of the Astronomical Council of the USSR Academy of Sciences in the 1960ies did not come to an end.

To our opinion nowadays all conditions are present to get a clear answer to the question of the existence of a Brazilian twin of the Tunguska meteorite. Especially the support of our colleagues in Brazil is requested since they have easy access to Latin American periodicals. The collection of information regarding the Tunguska event shows that many regional newspapers and journals include a substantial fraction of the data about exceptional natural phenomena.

Bearing in mind possible similarities of geophysical effects and accompanying appearances between the Tunguska event and its Brazilian twin, there is a special interest in seismograms and barograms of observatories which were working in the 1930ies. Probably such registration may provide the precise date of the Brazilian event.

Furthermore, it is necessary to check chronicles of missionaries. They may have survived in certain archives. Although the event happened more than 60 years ago, it is possible that witnesses among the Indians are still alive, or that the phenomenon has been included in the folklore. In this respect a collection of such material (as songs and tales) is of importance.

The research for the Brazilian twin of the Tunguska meteorite may also lead to a cooperation between scientists of the USSR and Latin America as well as with scientists of other countries who may contribute with valuable information. If the region of the explosion would be identified, we would like to organize a common Brazilian-Soviet scientific expedition in order to apply research methods used for 30 years in the region around the Tunguska site.

The Commision for Meteorites and Cosmic Dust of the Astronomical Council of the USSR Academy of Sciences asks all colleagues, scientific organizations and those who are interested to contribute any information about the "Brazilian twin" or to participate in comparisons of the given event with the Tunguska fall, to write to:

G. Andreev,
Chairman of the Tomsk Department of VAGO,
Astronomical observatory, Tomsk State University,
634010 Tomsk, USSR

Beyond any doubt, international cooperation will help to make progress in the research for an important natural phenomenon.

Reference

[1] L.A. Kulik, "The Brazilian twin of the Tunguska meteorite", *Priroda i Ljudi* 13–14, 1931, pp. 6-11 (in Russian).

The Perseids

On the Spatial Structure of the Perseid Meteor Stream

G.V. Andreev[1], *L.N. Rubtsov*[2], *I.I. Tarasova*[2]

The paper deals with the analysis of radar observations of the Perseid shower during the period 1964–1981. A mathematical model of the stream structure is constructed and the possible conditions of the Perseid origin and evolution are investigated.

The radar observations of the Perseid meteor stream made in the ionospherical laboratory of the Astrophysical Institute of the Tadjik Academy of Sciences from 1964 to 1981 are analyzed. Parameters of the equipment are listed in Table 1.

Table 1 – Main characteristics of the receiving-detecting equipment during observations. *Explanation of symbols:* $\text{РГ}\frac{\Phi}{L}\text{H}$ is a rombic aerial where Φ is half of the obtuse angle of the rombic aerial (degrees), L is the rombic side length (m), and H is the altitude (m) of the aerial above the Earth; $\text{СГ}\frac{n}{K}\text{P}$ is a broadside aerial with a reflector, n is the number of levels, and K is the number of side wave vibrations in every level; $\alpha_{\Lambda-K}$ is the minimum linear electronic train density calculated by the Lovell-Klegg formula; λ is the wave length; U is the echo altitude above the horizon; and Z_R is the zenith angle of the stream radiant.

Year	Date	Type of aerials		$\alpha_{\Lambda-K}$	λ	U	Echo direction	
	(Aug)	detecting	receiving	(10^9 sm^{-1})	(m)	(MKV)	A	h
1964 1965 1967 1968	11–13 07–15 10–18 12	$\text{РГ}\frac{65}{64}9$	$\text{РГ}\frac{65}{45}9$	3.25	17	7.65	90°	23°
1971	12	$\text{РГ}\frac{54}{22}7.5$	$\text{РГ}\frac{54}{22}7.5$	2.0	15	2.25	270°	27°
1973	09–15	$\text{РГ}\frac{54}{22}7.5$	$\text{РГ}\frac{54}{22}7.5$	0.8	15	2.25	270°	33°
1974	13	$\text{СГ}\frac{4}{5}\text{P}$	$\text{РГ}\frac{54}{22}7.5$	0.5	15	2.25	270°	33°
1975	09–13	$\text{СГ}\frac{1}{5}\text{P}$	$\text{СГ}\frac{4}{4}\text{P}$	1.0	15	2.25	270°	14°
1976	07–16	$\text{СГ}\frac{1}{5}\text{P}$	$\text{РГ}\frac{54}{22}7.5$	1.0	15	2.25	270°	27°
1977 1981	09–16 09–15	$\text{СГ}\frac{2}{8}\text{P}$	$\text{СГ}\frac{2}{8}\text{P}$	8.4	15	5.0	–	Z_R

The Perseid stream meteor rates have been determined by the fluctuation method [1]. Analysis of the integral distribution of the stream meteor rate showed that the position of the apparent stream maximum changes in different years, i.e. the stream's nodal position is continually varying. If the given effect is real, then the explanation of the apparent nodal "regression" in our view is the complex structure of the Perseid stream [2]. In fact, if there is narrow central condensation, then the position of the apparent maximum in the current year will depend on the orientation of the stream's true node and on the geographical meridian, as is the case for the Quadrantids. As to the true regression one can find it only for observations over a long period of time. According to D. Hughes [3] $\Delta\Omega = (3.8 \pm 2.7) \times 10^{-4\circ}$ per year. We show that the Perseids' nodal regression is actually very small and amounts to only 2×10^{-4} ° per year, taking into account planetary perturbations for the last 15 000–20 000 years. Since the narrow central condensation has been observed for about a century, we may conclude that the stream's compact part has spread over the entire orbit and that it is smaller than 1° in solar longitude. Consequently the thickness and width of this part are at most 0.016 AU and 0.0028 AU respectively.

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The mean value of the solar longitude for the observed maximum rate is equal to 139°0 ± 0°2 for all considered years. It agrees beautifully with data of many past years. It is necessary to note that the maxima for different echo durations between 1 and 20 seconds (i.e. different particle masses) coincide.

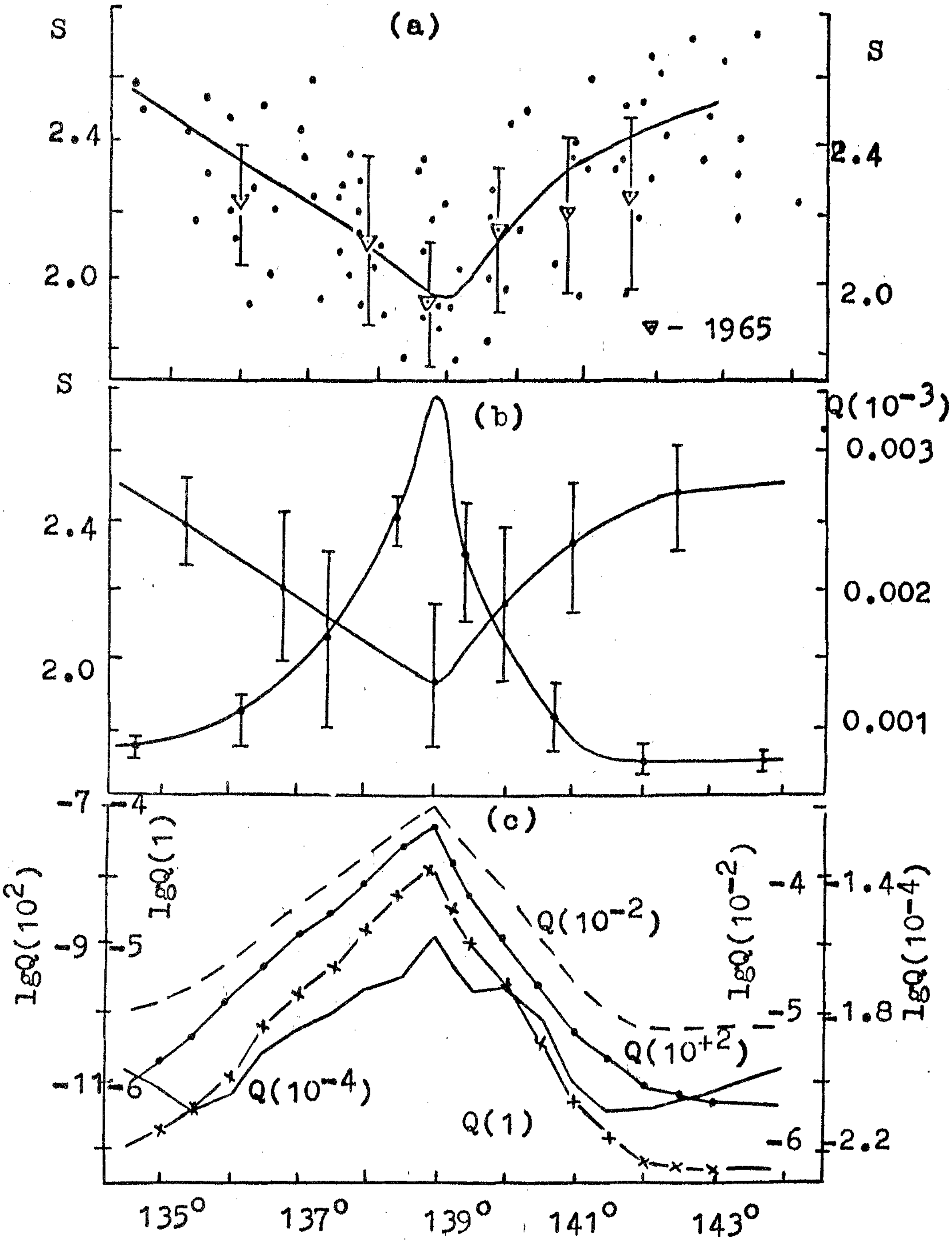

Figure 1 – (*a*) Individual values and smoothed curve of the mass distribution index. (*b*) Integral flux density Q (10^{-3} g) (km^{-2}h^{-1}) and mass index S versus solar longitude (1950.0). (*c*) Integral flux density $Q(m)$ for $m = 10^2, 10^0, 10^{-2}$ and 10^{-4} g versus solar longitude (1950.0).

For stream meteors with radio signal duration in the scope of 0.7 to 5(7) seconds, the value of the mass distribution index S was determined. About 80 determinations are plotted in Figure 1 (a) as a function of the solar longitude (1950.0). The standard deviations on S are given day by day for the year 1965, and a formal average of all mass index values is made. It should be noted that the standard deviations in S for the Perseids are a little greater than for the Geminid or Quadrantid meteor streams [4,5]. Perhaps, the great share of spread in $S(\lambda_\odot)$ is caused by a systematical mass index increase from 1964 to 1981. Although the statistical reliability of the fact which we noted is not great, we nevertheless obtain an average increase in $S(\lambda_\odot)$ of about 0.01 per year for all longitudes. This increase can be explained by ejection of mainly small components from the comet's surface during its latest perihelion passage. The mean minimum mass index value is equal to 1.94 ± 0.20 at $\lambda_\odot = 139^\circ\!.0 \pm 0^\circ\!.2$. In 1964 and 1981 the analogously reduced values were 1.8 and 2.0 respectively.

We found the Perseid flux density $Q(m)$ by modifying the Kaiser-Bel'kovich method [6]. The physical model of the meteor phenomena [7] was used and particle density of 0.3 gcm^{-3} was taken. For $m \geq 10^{-3}$ g, Figure 1 (b) gives the smoothed curve $Q(m, \lambda_\odot)$ obtained by averaging individual values with a step of about $0^\circ\!.7$ in solar longitude. Since our main aim is to study the global structure of the Perseid stream, one has to remember that possible additional maxima in the averaged curve $Q(m, \lambda_\odot)$ (for example at $\lambda_\odot = 137^\circ$) could not be noted. Figure 1 (b) shows that the flux density maximum $Q(10^{-3}) = 3 \times 10^{-3}$ particles $\mathrm{km}^{-2}\mathrm{h}^{-1}$ coincides with the one for large particles. For $m \geq 10^{-3}$ g the stream width at half maximum density is $1^\circ\!.8$. The integral values $Q(m)$ in the mass range of 10^{-4}–10^{2} g are plotted in Figure 1 (c). From this figure, it follows that the displacement in the particle mass variation is absent in the Perseid stream, distinguishing this stream from the Quadrantids and the Geminids. The flux density has been found by some authors: using visual data B.U. Levin [2] obtained $Q(10^{-3}) = 3.1 \times 10^{-3}$ in $S = 2$ and $\lambda_\odot = 139^\circ$ or $Q(10^{-3}) = 1 \times 10^{-3}$ in $S = 1.7$; according to D. Hughes [3] $Q(10^{-3}) = (3 \pm 0.5) \times 10^{-3}$ at the stream's maximum ($S = 1.85$, $\lambda_\odot = 138^\circ$); $Q(10^{-3}) = 3 \times 10^{-2}$ and $S = 1.58$ was obtained in Tomsk [6,8] from the rough results of radar observations in 1965. Thus our results are in good agreement with the calculations [2,3].

On the base of obtained flux density values and mass index we made estimates of meteor matter influx on the entire Earth during the Perseid activity. For the mass range 10^{-5}–10^{3} g, the total influx amounted 0.42 ton 50% of which fell for $\lambda_\odot$ between 138° and 140°.

To calculate the total number of particles in the stream and the stream mass we derived the equation of the Earth's path projection on the cross section plane at the node and the flux density distribution of the different masses along this projection. Studying these data we discovered that the flux density distribution was asymmetrical with respect to the mean orbital plane. This means that the areas between equal density lines above the mean orbital plane are greater than the analogous areas below it. Analysis showed that this asymmetry also followed from photographical and visual data. The angle between the projection of the Sun's direction and the semi-major axis of the cross section is 27°. Hence the gravitational and non-gravitational forces could not have caused this effect. The only possible explanation lies in the features of the stream formation. The estimate of the total number of particles intersecting the cross section of the Perseid stream at the node was obtained by integration of the flux density with the help of the method in [4]. For the masses from 10^{-3} to 10^{3} g the particle flux through the cross section amounts to 1.6×10^{12} particles per hour. The total number of particles in the stream is 1.7×10^{18} and the stream mass is at least 1.4×10^{16} g.

Usually, the Perseid stream formation is associated with the decay of comet 1862 III P/Swift-Tuttle. Taking into account the orbital size, one may assume that the decay of this comet was on the whole occurring at perihelion. It should therefore be expected that this area is the common intersection region of the individual meteor orbits. From analysis of 356 photographical meteor orbits we calculated the ecliptic coordinates of this area $\lambda_c = 84^\circ\!.4 \pm 4^\circ\!.5$; $\beta_c = 62^\circ\!.5 \pm 1^\circ\!.7$; $r_c = 1.51 \pm 0.09$ AU; the true anomaly equals $\nu_c = 284^\circ\!.1 \pm 4^\circ\!.4$. These data confirm the hypothesis of the Perseid formation by means of cometary decay on a rather small part of the orbit.

As a result of the processing of photographic catalogues the following stream mean orbital deviations from the comet 1862 III orbit were derived: $\Delta a = 1.6 \pm^{10.9}_{45.1}$ AU, $\Delta e = 0.0030 \pm 0.0996$,

$\Delta i = -0^\circ\!.7 \pm 1^\circ\!.9$, $\Delta\Omega = -0^\circ\!.05 \pm 2^\circ\!.40$, $\Delta\omega = -2^\circ\!.3 \pm 3^\circ\!.8$. Using the modern values of the Earth's path length in the stream and the theory [9], we determined the upper standard deviation of the orbital elements : $\Delta a \leq 0.3$ AU, $\Delta e \leq 0.00025$, $\Delta i \leq 0^\circ\!.4$, $\Delta\omega \leq 2^\circ\!.5$. As one can see, they are essentially smaller than the observed values. Analysis showed that the large variations were the result of the application of the two-body problem algorithm in the orbital elements calculation.

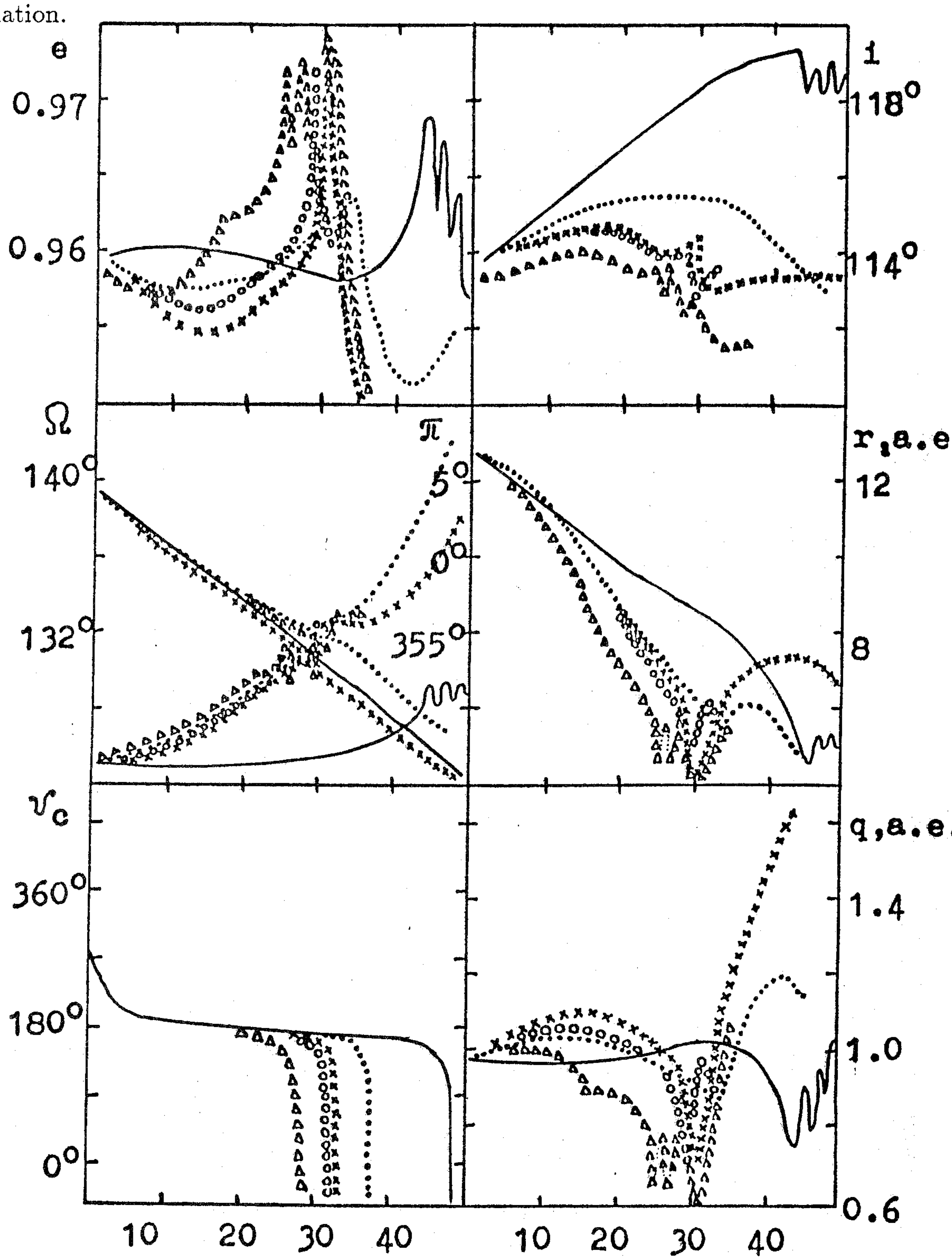

Figure 2 – Variations of the orbital elements of comet 1862 III P/Swift-Tuttle for up to 50 000 years ago. For more explanations, please refer to the text.

The individual orbits must not be used for the solution of the problem of the Perseid formation and evolution. So first of all we considered the comet orbital evolution and selected the favorable moments for its decay.

Figure 2 gives the results of the calculation of the comet's orbital evolution by the Alfan-Goryachev method [10] under the following conditions: (a) the orbits of the disturbing planets Jupiter, Saturn, and Uranus are not varying (full line); (b) for these perturbations only the first order secular terms are taken into account (dotted line); (c) the same as in (b), but the perturbations due to Neptune are added (open dots); (d) the same as in (c), but the perturbations due to the Earth are added (crossed line); and (e) the same as in (d), but the periodical perturbations are taken into account by numerical methods at the moment of close approaches (triangled line).

Figure 2 shows that the comet's evolution depends essentially on the integration conditions. Analysis shows that the main evolutionary transformations of the comet were caused by close approaches to Saturn (the first approach was as near as 1.07 AU in 1859.9, and then every 33 revolutions) and a catastrophical approach to Jupiter 25 000 years ago. Let us note that the paper [11] on the orbital evolution of comet 1862 III is not quite exact.

Discussing Figure 2, we conclude that from a physical point of view, the decay of comet 1862 III was more intense at the primary life period of the comet moving in the modern orbit, i.e. 25 000 years ago. One should pay great attention to the secular changing of the true anomaly ν_c of the "common point" of the Perseid orbit crossing. One can see that at the moment of approach to Jupiter, $\nu_c = 150°–180°$, irrespective of the integration conditions. This means that in the decay near perihelion the modern coordinates λ_c and β_c are opposite to the true ones.

In order to determine the decay velocities from the comet surface the various decay types (directed, isotropic, with different distribution of velocities and mass) were simulated. But none of them satisfies the necessary deviation signs of both the comet orbital elements and the elements of the stream mean orbit and the modern orbital elements and the Earth's path length. Agreement with these data is possible only under the following conditions:

(*a*) after the ejection practically all the particles passed through the sphere of influence of Jupiter (25 000 years ago) or Saturn (10 000 to 12 000 years ago), and
(*b*) a collision kind of comet decay occurred near aphelion 20 000–25 000 years ago.

References

[1] Andreev G.V., Lazarev R.G., *Astronomy and Geodesy* 7, Tomsk, 1979, pp. 41–45.

[2] Levin B.U., "The physical theory of meteors and meteor matter in the solar system", 1958.

[3] Hughes D.W, *Mon. Not. Roy. Astron. Soc.* 161:2, 1973, p. 113.

[4] Andreev G.V., Sukhotin A.A., *Meteor matter in the interplanetary space*, 1982, pp. 175–176.

[5] Andreev G.V., Episheva A.E., Rubtsov L.N., Tarasova I.I., *Izvest. Tadg. SSR. Otd. phis.-mat. and geol.-chem. scien.* 3, 1985, pp. 37–50.

[6] Andreev G.V., Ryabova G.O., *Meteor matter in the interplanetary space*, 1982, pp. 129–130.

[7] Bel'kovich O.I., Sulejmanov N.I., Tokhtas'ev V.S., *Meteor matter in the interplanetary space*, 1982, pp. 88–101.

[8] Svetashkova N.T., *Astron. circ.* 1074, 1979, pp. 1–3.

[9] Andreev G.V., *Meteor bodies in the interplanetary space and the Earth's atmosphere*, Dushanbe, 1984, pp. 3–4.

[10] Andreev G.V., Episheva A.E., Mugruzina O.A., Rubtsov L.N., *Astronomy and Geodesy* 13, Tomsk, 1985, pp. 79–90.

[11] Hamid S.E., *A.J.* 56:5, 1951, pp. 126–127.

A Double Maximum for the 1989 Perseids is Real!

V. Martynenko, A. Levina, A. Grishchenyuk, D. Sukhov

An overview is given of Crimean observations of the 1989 Perseids, confirming the existence of a double shower maximum.

From August 1 to 17, 1989, 44 observers carried out a watch of the Perseid shower. The observers were members of the Crimean Amateur Astronomical Society and of the Crimean branch of the All-Union Astronomical-Geodetical Society.

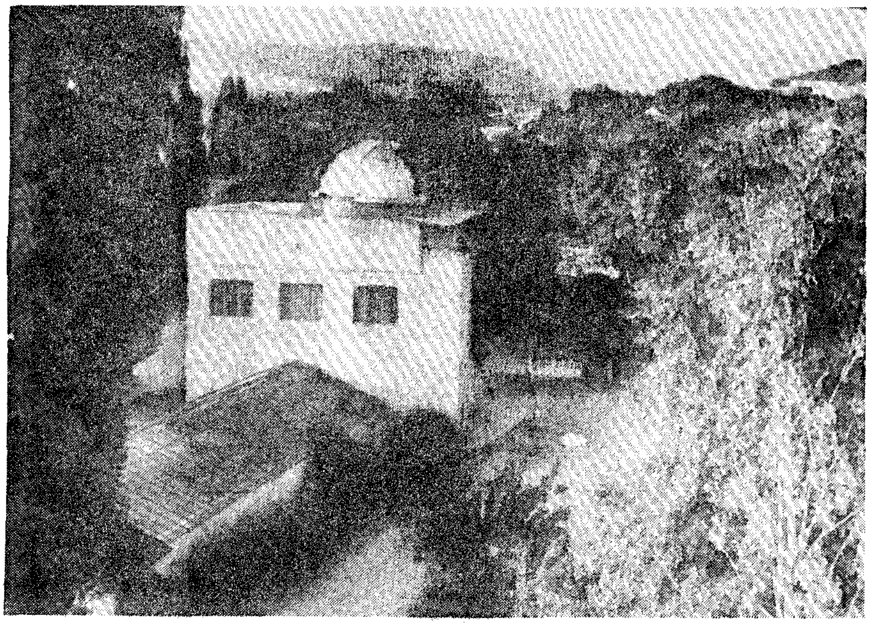

Figure 1 – Astronomical school observatory in L'govskoye. Excellent observations of the 1989 Perseids were carried out here.

Figure 2 – Group of observers of the Crimean Ama eur Astronomical Society during meteor expedition nr. 111 fo the study of the 1989 Perseids.

Observations were carried out on the base of the Astronomical observatory of the Crimean Young Technicians' Station, on the G.O. Zateishschikov Meteor Station (Simferopol), on the meteor station in Sudak, on the school observatory in the village of L'govskoye (East Crimea, see Figure 1), on the tourist camp on Mount Demerji, and on Cape Tarkhankout.

In total, 5150 meteors were recorded, 3100 of which were Perseids. The most experienced observers were:

> A. Levina, A. Grishchenyuk, V. Martynenko, S. Zhitelzeif, V. Krutko, M. Kitin, V. Glinka, D. Sukhov, E. Bykova, M. Groznov, O. Bubnoskaya, M. Rogova, and S. Nikolayev.

Three groups of observers counted Perseids over the entire sky, and besides this, the East was checked by three to four experienced observers. Most Perseids were recorded in the night of August 12–13: 258 meteors were registered in Simferopol (limiting magnitude between 4.8 and 5.8), 196 of which were Perseids. In Sudak, 560 meteors were registered (352 Perseids), and in L'govskoye 721 meteors of which 568 Perseids.

Figure 3 – Crimean meteor expedition nr. 110 (July 1989) for the study of α-Lyrids and other showers. The picture shows a training "observation".

One of the shower peculiarities this year was a lack of bright meteors. At the nights of maximum, August 11–12 and 12–13, the brightest meteors were of magnitude −4 for all groups. One Perseid fireball of magnitude −5 to −7 was spotted on August 10 at 22^h17^m UT. It was seen from three points.

Another conclusion is the brilliant confirmation of the shower's double maximum. Fast increasing rates were observed before daybreak on August 12 (the ZHR reached 115) and again, after a decrease, before dawn on August 13. (the mean ZHR increased from 56–66 to 130; the highest values obtained were between 150 and 170).

Probably most meteors observed in the USSR were seen at $\lambda_\odot \geq 138\overset{\circ}{.}5$ and $\lambda_\odot \geq 139\overset{\circ}{.}75$. In the village of L'govskoye, the sky was most close to standard conditions. The main group worked there. Observers at Simferopol noted an abundance of Perseids of magnitudes 0 to 1. This was partially due to the illumination by the Moon of the haze along the horizon.

For the area with $Z \leq 35°$, the exponent of luminosity function κ, expressed in number of meteors per square meter and per second, was equal to 2.38 on August 11–12 and 3.12 for the next night. This exponent was calculated from the relations:

$$\log \kappa = \frac{\log I(M_2) - \log I(M_1)}{M_2 - M_1} \qquad \text{and} \qquad I = \frac{N}{ST},$$

where N is the number of meteors, S the area, and T the effective observing time.

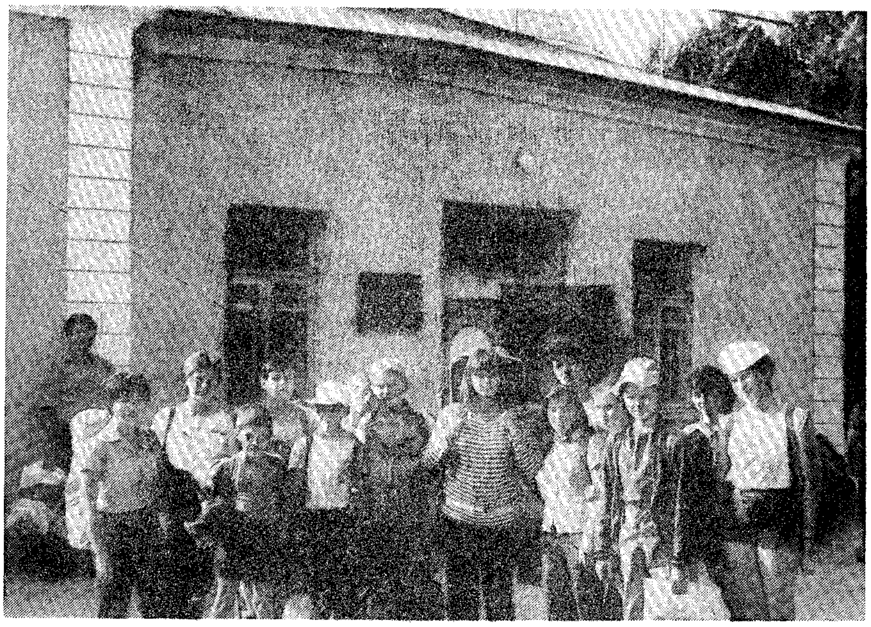

Figure 4 – Participants of meteor expedition nr. 110 at the Astronomical Observatory in Simferopol.

Figure 5 – Participants of the Crimean meteor expedition near the school observatory in L'govskoye. The leftmost person is Anna Levina.

The observers of the expedition in L'govskoye studied spatial and time distribution characteristics of the Perseid shower as well. Dense clots of meteors (bundles, twins, etc.) were found again. One such clot was clearly distinguished from 0^h08^m to 0^h32^m UT on August 13.

Observers at Simferopol renewed the telescopic study of the total radiation area to try to find out whether telescopic Perseid radiants make a diffuse area or whether they are located on a particular spot of the total radiation area. The preliminary results thus far do not yet allow to decide this matter. No telescopic radiant coincided with the main one. More details will be given in another paper.

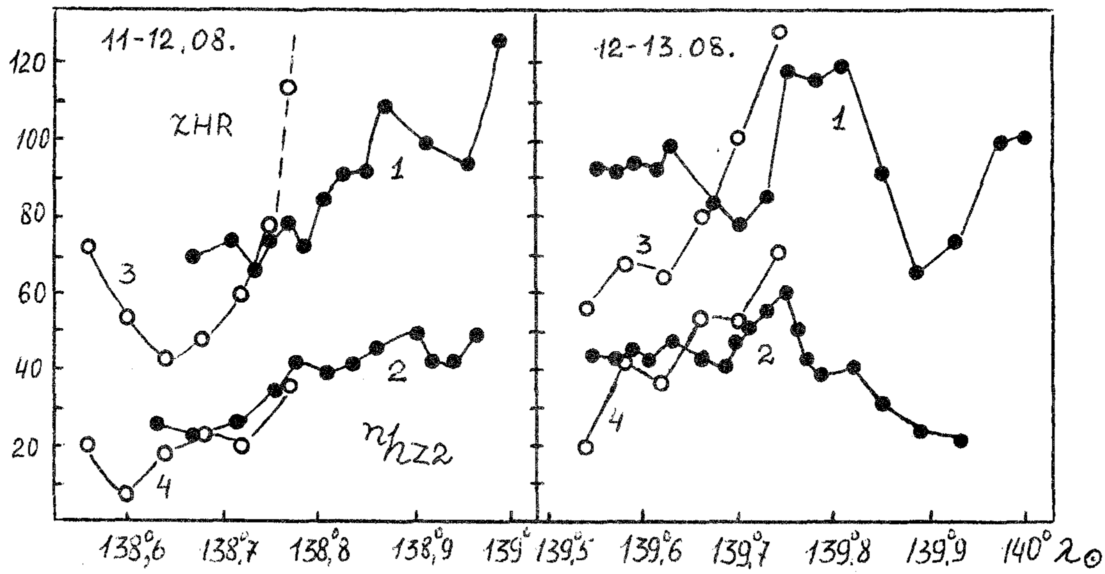

Figure 6 – Averaged ZHR-curve (1) and $n_{h\geq 2}$ for Perseids brighter than magnitude 2 for August 11–13, 1989. For this period, the same data are given, using only Crimean observations (3 and 4 respectively). Increases if Perseid activity in 1988 and 1989 coincide, indicating evidence for some stable features in the stream.

Figure 6 shows the mean ZHR-profile as estimated after preliminary data from Crimean observers. All other USSR data were not yet available for analysis so far.

On Groups of Bodies in the Perseid and Geminid Meteor Showers

A.I. Grishchenyuk

The incidence of meteor occurrences in Crimean observations of the Perseids and the Geminids is compared to a Poisson distribution. It is concluded that meteor groups existed for the Perseids in 1972 and 1980–82. but not for the Geminids. The difference between both streams is attributed to their different particle structure. It is also suggested that groups occur as a consequence of disintegration of particles under influence of solar radiation, thus implying a correlation between the occurrence of meteor groups and the solar activity.

In spite of intensive studies of meteors by visual and radar methods [1,2,3] the problem of the existence of groups of meteors is not solved so far. Many observers note unevenness in meteor appearances [4,5]. This might be explained by illusion, distracting the attention to bright meteors, tiredness of the observer, etc. On the other hand, the hypothesis of the existence of groups of meteors in a shower can also be proposed. If the appearance of a meteor can be seen as an accidental phenomenon, then the appearances should then be described as a Poisson law. The problem is then reduced to the comparison of observations and calculations.

The data of homogeneous series of observations, organized by the Crimean Meteor Station under direction of V.V. Martynenko, were used for analysis. A group of experienced observers recorded meteors in a sky area about 100° in diameter. Only observations carried out in cloudless intervals and under identical sky conditions (limiting magnitude between 6.2 and 6.5) were used for processing.

The number of unit time intervals in which $k = 0, 1, 2, \ldots$ meteors appeared is, according to a theoretical Poisson dirstribution, given by:

$$N_{t,k} = T\,\frac{E^{-\lambda}\lambda^k}{k!},$$

where $\lambda = N/T$, with N the total number of meteors, T the total observing time, and λ the average number of meteors seen per unit time interval. The agreement between theory and observation can then be checked using the χ^2 criterion.

As an example, we show in Table 1 how the observations of August 12–13, 1982 were processed.

Table 1 – Comparing the incidence of meteor apparitions with a Poisson distribution.

k	$N_{o,k}$	$N_{t,k}$	χ^2_o
0	58	47.74	2.22
1	44	63.35	5.83
2	47	42.05	0.58
3	26	18.16	2.93
4	3		
5	1	8.21	1.24
6	1		
Tot	180	179.93	12.80

The total number of Perseids in Table 1 is $N = 239$ and the net observing time is $T = 180$ minutes, whence $\lambda = N/T = 1.63$. $N_{k,o}$ $(k = 0, 1, 2, 3, 4, 5, 6)$ is the observed number of one minute time intervals in which k meteors were recorded and $N_{k,t}$ is the corresponding theoretical number, predicted by a Poisson distribution. In the last column column of Table 1, the value of χ^2_o is computed. The values for $k = 4, 5, 6$ were combined to obtain significant data (at least 5 intervals in one class). The total value of χ^2_o equals to 12.80. For $\nu = 3$ degrees of freedom, the value of χ^2 corresponding to a significance level of 0.05 equals $\chi^2_t = 7.8$. It corresponds to admitting the hypothesis $\chi^2_o \geq \chi^2_t$ with a probability of 95%.

Table 2 – Results of applying the Poisson test to Perseid and Geminid observations.

Perseids					Geminids				
Date	N	χ^2_o	χ^2_t	ν	Date	N	χ^2_o	χ^2_t	ν
1971 Aug 13	331	27.9	9.5	4	1971 Dec 13	104	3.3	7.8	3
1971 Aug 14	172	19.0	7.8	3	1972 Dec 13	146	2.6	6.0	2
1972 Aug 13	171	5.2	7.8	3	1972 Dec 14	223	2.5	7.8	3
1972 Aug 15	264	3.1	11.6	5	1974 Dec 13	140	2.8	6.0	2
1975 Aug 12	150	6.5	11.6	5	1975 Dec 14	111	3.8	7.8	3
1975 Aug 13	148	6.4	7.8	3	1977 Dec 13	105	1.6	7.8	3
1977 Aug 13	180	4.7	7.8	3	1981 Dec 12	103	6.6	9.5	4
1978 Aug 12	128	3.8	6.0	2	1982 Dec 13	158	2.9	6.0	2
1978 Aug 13	125	1.7	7.8	3	1983 Dec 13	204	5.4	9.5	4
1979 Aug 13	130	3.8	6.0	2					
1980 Aug 13	240	11.9	9.5	4					
1981 Aug 12	264	7.9	7.8	3					
1981 Aug 13	258	9.7	9.5	4					
1982 Aug 13	239	12.8	7.8	3					
1983 Aug 14	101	3.6	7.8	3					
1985 Aug 14	103	3.7	7.8	3					

The results of the processing are given in Table 2, where N is the number of meteors used in the analysis, χ_o^2 is the calculated value of the χ^2-criterion, χ_t^2 is the theoretical value corresponding to a 0.05 significance level, and ν is the number of degrees of freedom. From Table 2, one can deduce the existence of meteor groups in the Perseid showers of 1972 and 1980–1982; in the Geminid shower, however, groups do not occur. This difference might be explained by peculiarities of the particle structure of both streams [6,7]. The Perseid particles are fragile, containing much gas and water, whereas the Geminids particles are very dense, consisting of iron. A mechanism responsible for the appearances of groups of meteors in an interval of 60 to 180 seconds can be based on the findings of Radzievsky [3] concerning desintegration of particles under influence of solar radiation. The short time interval groups, the so-called "chains", can be explained by electrical forces in the magnetosphere.

Radar observations of the Geminids in 1981 [5] showed that 4-5% of the total meteor flux were grouped occurrences. This conclusion is very interesting and can be used for analysis of other showers.

The comparison of the observed number of occurences with the predicted ones is very rough, and leads only to a qualitative result (there are groups, or there are no groups), as opposed to the quantitative method suggested in [2,5]. To conclude, it should be noted that the probability of grouped occurences is correlated to the solar activity, so that the appearance of the Perseids of 1991–1993 should display even more unevenness.

References

[1] I.S. Astapovich, "Meteor Phenomena in the Atmosphere of the Earth", Moscow, 1958 (in Russian).

[2] A.V. Kapnob et al., *Astronomical Herald* 18:1, 1984, pp. 44–51 (in Russian).

[3] V.V. Radzievsky, *Rep. USSR Acad. Sci.* 51, 1954, pp. 49–52.

[4] I.S. Gorban, V.V. Martynenko, *Bulletin of VAGO* 11:8, 1951, pp. 22–23 (in Russian).

[5] Yu.A. Pupyshev et al., *Meteor Propagation of Radio waves* 16, Kazan, 1980, pp. 3–9 (in Russian).

[6] V.N. Lebedinets, *Astronomical Herald* 21:1, 1987, pp. 65–73 (in Russian).

[7] V.N. Lebedinets, *Astronomical Herald* 21:3, 1987, pp. 262 a.f. (in Russian).

Radio observations of the 1988 Perseids

Jeroen Van Wassenhove

Radio observations of the 1988 Perseids are presented and discussed.

1. Introduction

Among radio observers, the Perseids are the best known meteor shower. It also gives the occasion to a new observer to make his first steps in radio meteor astronomy as this shower can be detected with low sensitive equipment. Radio reports from three different countries were received:

> Luc Gobin (B), Maurice De Meyere (B), Rik Van Laethem (B), Dirk Artoos (B), Christian Steyaert (B), Public Observatory Urania (B), Jeroen Van Wassenhove (B), Gotfred Møbjerg Kristensen (DK), and Ingo Reimann (D).

As a single observation can not be compared with others, only complete series of observations were used in this analysis (listening several days during the same period of time without changing frequency and equipment set-up). Observations lasting less then 30 minutes were eliminated for statistical reasons.

2. Observations

Some radio stations changed frequencies during the Summer of 1988. For this reason, the observations were not corrected for the influence of the position of the radiant with the so-called "Observability Function", as this could lead to over- or undercorrecting which leads to incorrect results and interpretation. So all the data presented are raw data.

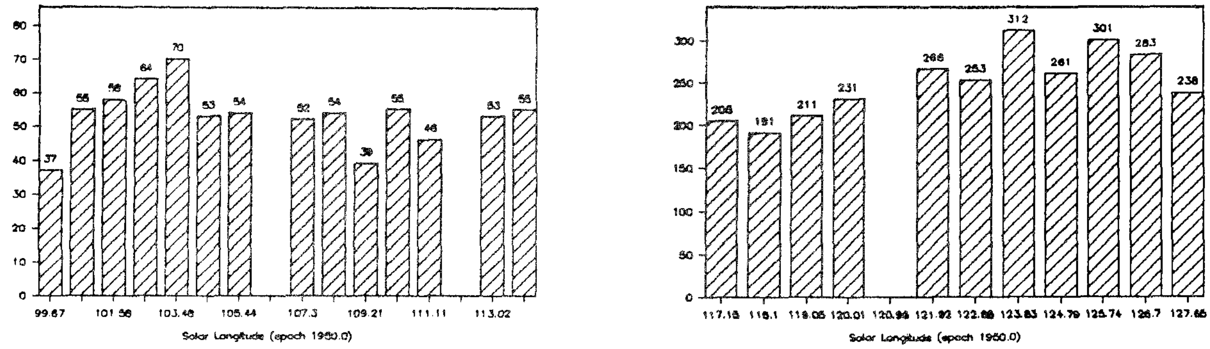

Figure 1 – *Left:* radio observations by Maurice de Meyere at 66.17 MHz between 20^h30^m and 21^h00^m UT. *Right:* radio observations by Luc Gobin at 66.17 MHz between 4^h00^m and 5^h00^m UT.

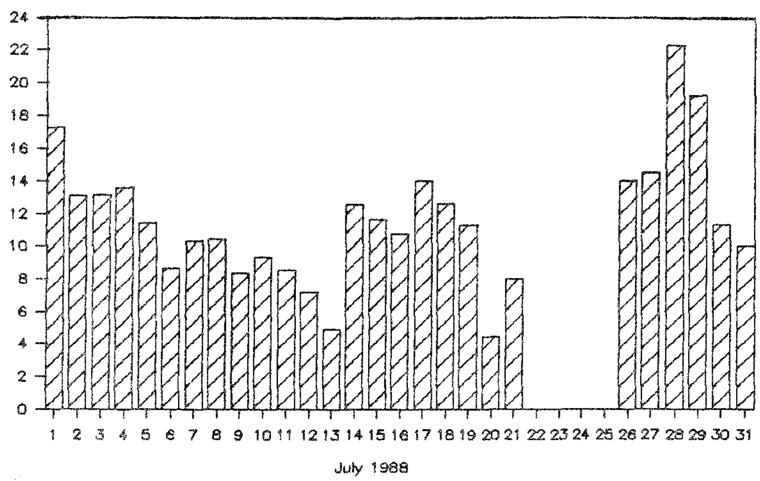

Figure 2 – Radio observations by G.M. Kristensen at 100.50 MHz in July 1988.

Several observers already listened in July. Their results are presented in the corresponding graphs. Some observers had troubles with disturbances and Sporadic-E.

Begin August, most radio observers got into action. A lot of them listened during too irregular periods, too short periods or on different frequencies. These observations also have their value, but radio observations can only be compared if an observer listened several days during the same period of time (half an hour is an *absolute* minimum) without changing his frequency and equipment set up. Comparing observations of successive days with different periods is scientific nonsense.

Observations which satisfy at the stated conditions are shown. Several observers had disturbances due to Sporadic-E and local radio stations. Especially those who listened on the 3 m band (87.50–108.00 MHz) had trouble. Some observers even stopped. On the 4 m band (65.00–73.00 MHz) there were less disturbances.

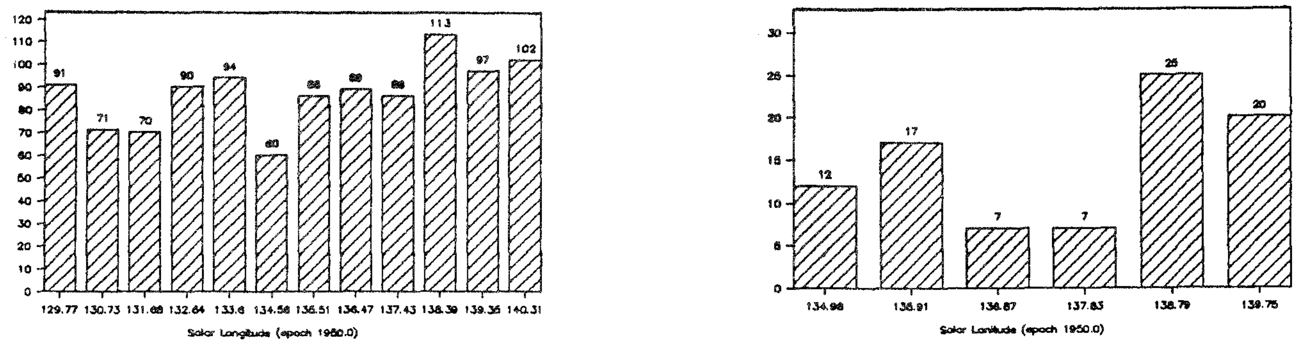

Figure 3 – 1988 Perseid observations by *(left)* M. De Meyere at 66.17 MHz between 9^h00^m and 10^h00^m UT, and *(right)* G.M. Kristensen at 100.50 MHz between 19^h00^m and 20^h00^m UT.

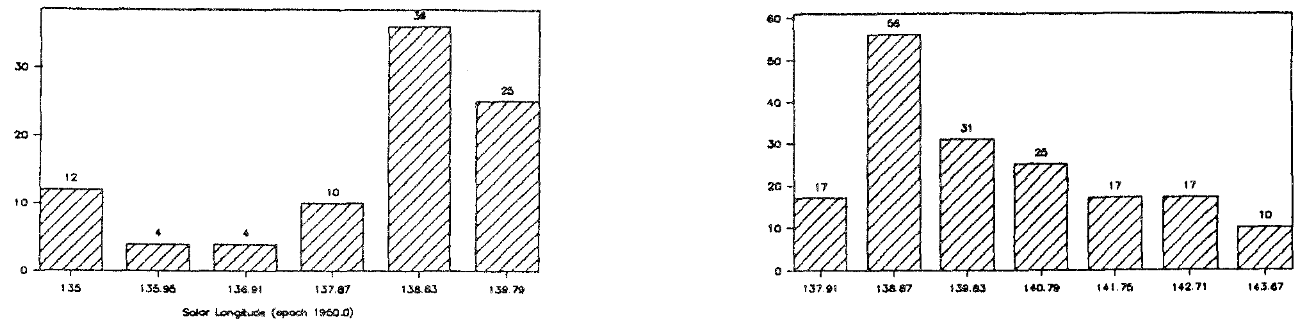

Figure 4 – 1988 Perseid observations by G.M. Kristensen at 100.50 MHz between *(left)* 20^h00^m and 21^h00^m UT, and between *(right)* 21^h00^m and 22^h00^m UT.

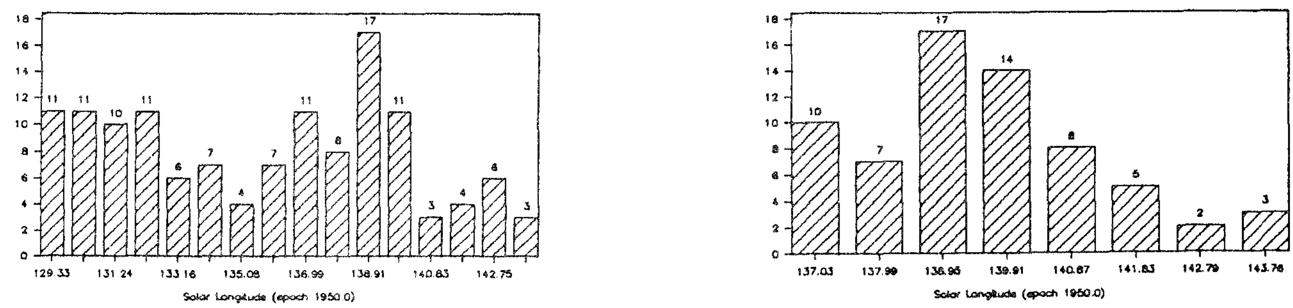

Figure 5 – 1988 Perseid observations by Ingo Reimann at 105.60 MHz between *(left)* 22^h00^m and 23^h00^m UT, and between *(right)* 23^h00^m and 24^h00^m UT.

3. Discussion

When one evaluates the observations of the Aquarids, no "real" maximum can be found. The activity fluctuates a lot, with some peaks around July 27–29. Unfortunately, the amount of data (only two observers) is too small to make a detailed activity profile of the δ-Aquarids.

With the data of the 1988 Perseids we were able to calculate the maximum [1] of each series of observations. The results are shown in Table 1.

There are some differences between the calculated maxima, probably because there are no common periods. The results were combined and this gives us the final date of August 12, $2^h\!.03 \pm 6^h\!.2$, which corresponds with a solar longitude (1950.0) of $\lambda_\odot = 139^\circ\!.05 \pm 0^\circ\!.25$. As this result is based on only six series of observations, it is quite possible that it might differ from the visual result.

Remarkable is the fact that, again, Sporadic-E increased. As already mentioned, several observers could not listen due to this phenomenon. Except for lightning and inversion, it is the only thing that can disturb a radio meteor observation. It also confuses the unexperienced observer. Sporadic-E is caused by the activity of the Sun, and as it increases from month to month at this moment, sooner or later every radio observer will have to deal with this phenomenon. When the activity of the Sun will be at maximum, decent observing will only be possible at night, I am afraid.

Table 1 – Maxima of the 1988 Perseids calculated from radio observations.

Observer	Period (UT)	Maximum (UT)
M. De Meyere	09^h00^m–10^h00^m	Aug 11 $14\overset{h}{.}16 \pm 4\overset{h}{.}22$
G.M. Kristensen	19^h00^m–20^h00^m	Aug 12 $05\overset{h}{.}21 \pm 5\overset{h}{.}93$
G.M. Kristensen	20^h00^m–21^h00^m	Aug 12 $03\overset{h}{.}38 \pm 2\overset{h}{.}77$
G.M. Kristensen	21^h00^m–22^h00^m	Aug 12 $02\overset{h}{.}45 \pm 2\overset{h}{.}61$
I. Reimann	22^h00^m–23^h00^m	Aug 12 $02\overset{h}{.}68 \pm 6\overset{h}{.}09$
I. Reimann	23^h00^m–00^h00^m	Aug 12 $08\overset{h}{.}32 \pm 6\overset{h}{.}00$

References

[1] C. Steyaert, "Berekenen van het maximum van een meteoorzwerm", VVS Werkgroep Meteoren, TN 1 (in Dutch).

JAS Meteor Section 1989 Summer Results

Alastair McBeath

A brief review of work by JAS Meteor Section members in 1989 July and August is presented and discussed with especial reference to the Perseid meteor stream.

1. Introduction

The early months of 1989 were marred for the UK observers by some indifferent weather conditions for the most part, but the summer brought far better skies. During July and August, 366.7 hours of naked-eye and 52.4 hours of photographic observation were possible, yielding 3134 visual and 10 photographic meteors. Observers were:

> Shaun Ankers (P), Thomas Banks, Roy Barclay, Neil Bone (P), Debbie Borrel, Walter Bradford, David Cameron, Andy Chapman (P), Jeremy Drew, Le Forbes et al., Shelag Godwin, Petere Hallett, Mark Harris, Terry Holmes (P), Mike Hutchings, Sebastian Jay, Craig Johnson, Richard Livingstone, Lee Macdonald, Julie Maginn, Tony Markham, Alastair McBeath (P), Stewart Moore, Graham Pointer, Chris Reitter, Ian Rigney, Alan Smeaton (FRG), Adrian Tighe, Martin Trotter, Simon Wragg, Malcolm Wright.

Photographers are denoted by the abbreviation "(P)", while all observers were UK-based except where noted.

As usual, only reliable, good condition data were used from British sites in the analyses, which were carried out as detailed in [1], except for the sporadic CHRs, which were calculated as shown in [2]. The mean limiting magnitude was +5.8 and the mean cloud percentage 3% ($F = 1.03$).

Table 1 gives the showers under observation, together with the number of meteors available for analysis after the normal reductions for conditions and observer inexperience.

Table 1 – Showers observed and analyzed meteor numbers.

Shower	Meteors	Showers	Meteors
Perseids	758	δ-Aquarids	53
α-Capricornids	34	α-Cygnids	30
α-Aurigids	25	ι-Aquarids	22
Capricornids	16	Ophiuchids	6
κ-Cygnids	1	α-Lyrids	0
Sporadics	620		

Viable analyses were thus possible only for the Perseids and sporadics, though some tentative results were produced for the δ-Aquarids too. Few δ-Aquarids were differentiated into northern and southern components—a difficult task at best due to the radiants' low elevation from Britain—so only combined information for this shower is given here.

2. Magnitude distributions

Table 2 presents the global magnitude distributions for the Perseids, δ-Aquarids and sporadics.

Table 2 – Global magnitude distributions of the 1989 Perseids, δ-Aquarids and sporadics, as obtained from JAS observations.

Magnitude	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	$\overline{m}$	$\overline{m}_{6.5}$	r
Perseids	22	31	56	111	138	138	143	89	30	758	1.58	2.21	2.13
δ-Aquarids	1	0	2	3	5	10	20	10	2	53	2.43	3.13	3.05
Sporadics	2	3	16	44	65	144	203	107	36	620	2.49	3.19	3.12

3. Meteor rates and train details

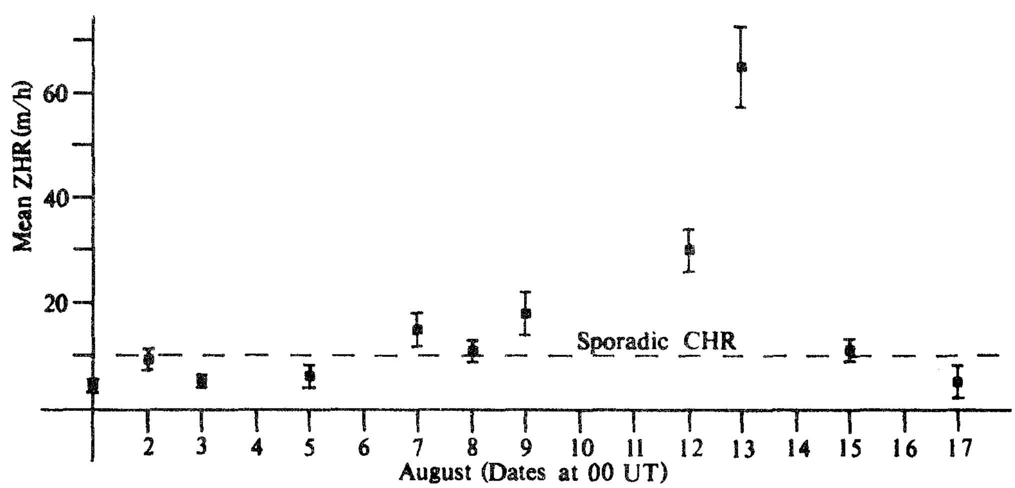

Figure 1 – 1989 Perseid activity as derived from the JAS Summer observations.

Figure 1 shows the Perseid activity graph derived from the 1989 August results, together with a plot of the mean sporadic CHR (10.4 ± 0.6) during the month for comparison. Insufficient δ-Aquarids were seen to allow a similar curve to be drawn up for them.

The mean peak Perseid ZHR on August 12–13 was 65.4 ± 13.0, though some individual ZHRs suggested rates in the 75–80 range on that night.

These are given for the Perseids and sporadics in Table 3. Overall, 33% of the Perseids and 6% of the sporadics showed persistent trains. About 6% of the δ-Aquarids were also trained.

Table 3 – Meteor trains seen by JAS observers.

	Perseids		Sporadics	
Magnitude	Number trained	Mean duration (s)	Number trained	Mean duration (s)
-3^-	18	5.9	1	4.0
-2	26	2.4	0	
-1	38	1.9	6	1.2
0	57	1.9	8	2.1
$+1$	51	1.4	9	0.9
$+2$	39	1.1	9	1.4
$+3^+$	18	0.6	3	1.2

4. Photographic results

In 1988 summer, 31 meteor trails were recorded in 63.3 camera hours during the Perseid epoch, a capture rate of about one meteor for every two camera hours. In 1989, the capture rate dropped to only one meteor in almost 5.25 camera hours, despite the number of bright visual events being somewhat higher.

5. Discussion

In all, the Perseid and sporadic results show essentially the same features as were seen in 1988, though activity from much closer to the Perseids main peak was seen in 1989. In correspondence, some observers suggested that Perseid rates fell as the night proceeded, though this cannot be definitely confirmed from these results. Individual ZHRs from this night suggest a fairly stable level of Perseid activity on the whole, with neither the decreasing rates expected from the prediction in [3] nor the increasing activity forecast in [4] seeming to occur.

The δ-Aquarids are never easy to observe fully from Britain, and the data produced this year, though scanty, are rather better than has been obtained for some years by the Section. Although rates determinations were not possible (observed activity rarely exceeded 3 meteors per hour) and an analysis for each component was not practical, the mean magnitude and paucity of trains fall well into line with the details given in both [5] and [6].

References

[1] A. McBeath, "JAS Meteor Section Visual Results: 1988 Perseids", *WGN* 16:6, December 1988, pp. 195–197.

[2] A. McBeath, "JAS Meteor Section Sporadic Analysis, 1984–1988", *WGN* 17:6, December 1989, pp. 267–272.

[3] G.H. Spalding, "Meteor Diary", *The Handbook of the British Astronomical Association 1989*, British Astronomical Association, 1988, pp. 96–97.

[4] P. Roggemans, "The Perseid Meteor Stream in 1988: A Double Maximum!", *WGN* 17:4, August 1989, pp. 127–137.

[5] G.W. Kronk, "Meteor Showers—A Descriptive Catalog", Enslow Publishers.Hillside N.J., 1988, pp. 121–131

[6] P. Roggemans, "Handbook for Visual Meteor Observations", Sky Publishing Corporation.1989, pp. 121–124

Forward Scatter Data and the Population Index

Jeroen Van Wassenhove

The computation of the population index r from forward scatter data is discussed.

1. Introduction

When a radio observer hears a meteor reflection he writes down the time, strength, duration and a description of it. The duration is estimated which results in large errors, especially for those lasting less then 1 second [1]. For this reason only durations of 2 seconds and longer were used in shower analysis in the past [2]. The strength (audio signal) of the meteor reflection is also estimated, on a scale from 1 (very weak) to 5 (very loud). Unnecessary to mention that this scale is very subjective. Each radio observer has his own definition of e.g. loud and very loud. The solution for measuring both parameters with sufficient accuracy can be found in using electronical equipment.

Two observers managed to connect electronical measurement equipment to their receiver. Maurice De Meyere (B) used a pen recorder which enabled to measure the amplitude of each meteor reflection. Luc Gobin (B) made himself a special duration meter in order to determine the duration of each meteor reflection with high accuracy. In both cases the real signal strength was measured, *not* the audio signal strength.

2. Results

Maurice De Meyere recorded 741 meteors in the period of August 7 till 13 between 20^h50^m and 21^h20^m UT. Luc Gobin measured the duration of 1723 meteors in the period of July 15 till August 2 between 4^h00^m and 4^h30^m UT.

Both observations were split into logarithmic classes. Each class contains a least 10 meteors. Then a cumulative distribution was made, plotted on a doubly logarithmic scale. After that, we calculated via linear regression the following relation:

$$\log N = C - 2.5 \log r \log D$$

with N the number of reflections, r the population index, D the duration or the amplitude, and C a constant, from which we derived the r-value.

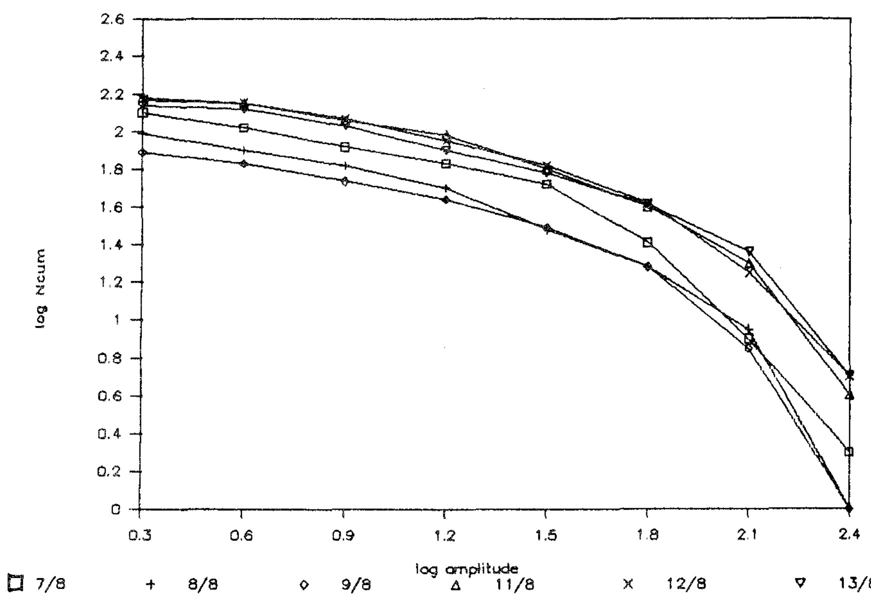

Figure 1 – Amplitude distribution of Maurice De Meyere, plotted on a doubly logarithmic scale for each day.

Figure 1 shows the amplitude distribution of each day plotted on a double logarithmic scale (for M. De Meyere) As the maximum of the Perseids comes nearer, the number of meteors increases. This can be seen on the figure by the translation of the curves to the top. At the left side of the graph, the translation goes linear, but at the right side it does *not*. This means that, as the maximum approaches, the number of bright meteors increases more rapidly in comparison with the rather faint ones. As the calculation of the population index r is based on the results of figure one, this trend is also found in Figure 2 (left) The average r-value for this period (August 7–13) amounts to 1.94 ± 0.25.

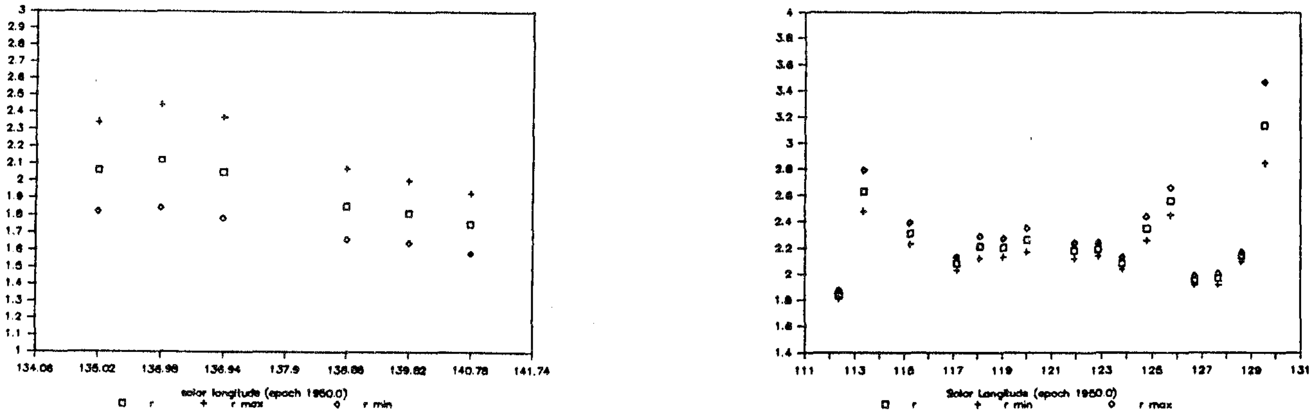

Figure 2 – The population index r as obtained from radio observations by M. De Meyere *(left)* and L. Gobin *(right)*.

It must be said that the presented r values in Figure 2 (left) are a mixture of the r-values of the Perseids and the sporadic meteors as radio observers can not distinguish shower meteors from the sporadic background due to the used observing technique.

Figure 2 (right) shows the r-values derived from echo durations (of Luc Gobin). No pattern can be found, only some fluctuations. (especially after $\lambda_\odot = 125°$) These r-values are mainly due to the sporadic background, with some influence of the δ-Aquarids. The average r-value for this period (July 15–August 2) amounts to 2.25 ± 0.30.

3. Remarks

Other radio observers (Public Observatory Urania (B) and Knud Bach Kristenson (DK)) also made pen recordings, but at the time of this writing, their results were not yet available.

Using forward scatter data for determining r values is much more objective than using visual data, because:

- A radio observer's perception coefficient is almost 1. E.g. if a radio observer can detect meteors to magnitude 7.0, he will have heard all the meteors up to magnitude 6.0, which is very different from the situation with a visual observer; and
- The accuracy of the used equipment is very high and can be verified. The estimated visual magnitude of a meteor, on the other hand, is relatively inaccurate (depends on the experience of the observer) and is rather difficult to verify.

Its clear that from now on, such computations will have to be done more often.

References

[1] C. Steyaert, "Reflection Duration Determination: An Experiment", *WGN* 15:4, August 1987, pp. 114–116.

[2] J. Van Wassenhove, "Quadrantids 1987 in Belgium", *WGN* 15:5, October 1987, pp. 171–172.

Observational Results

An Analysis of Sporadic Meteors

Alastair McBeath

We present a five-year analysis of visual sporadic results of the JAS Section, obtained during the period 1984–1988. Some suggestions for future work are made.

1. Introduction

It has long been established that sporadic meteor activity fluctuates both diurnally and annually in terms of observed meteor rates—see for example [1] or [2]—but whether there are other variations, such as in magnitude distribution or train proportions, has been less well-studied. While it is relatively easy to extract data from a single year's visual sporadic results to show any diurnal changes, because of adverse weather or lunar-lighting conditions, this is not a long enough period to ensure reasonable coverage for annual variations. Thus, a five-year sample of such information was examined in preparing this analysis.

During the five year period, defined as running between 1984 January 1–2 to 1988 December 31–32, some 3032.92 hours of visual observation from UK sites were reported and 11 097 sporadic meteors seen. Sixty-three individual observers and members of five astronomical societies contributed to these totals, as listed below:

> Shaun Ankers, Thomas Bank, Roy Barclay, Anne Barrowcliffe, Kevin Blaylock, Neil Bone, Huw Boulton, Walter Bradford, Kevin Buckley, Robert Calvert, Andy Chapman, Edward Chester, Alison Chisholm, John Copsey, Michael Dale, Elspeth Edward, Gavin Fitzgerald, Kenneth Fraser, Fraserburgh Academy Astronomy Club, Norman Galloway, Stephen Gardiner, Shelagh Godwin, Peter Grego, Guildford Astronomical Society, Peter Hainsworth, Peter Hallett, Mark Harris, Derrick Hasted, Terry Holmes, Nigel Houlton, Christpoher Howell, Mike Hutchings, Sebastian Jay, Simon Jenner, Jason Jones, Trevor Law, Richard Livingstone, Darren Lowe, Lee Macdonald, Jonathan MacNab, Tony Markham, Alastair McBeath, James McLean, Martin Middleton, John Mitton, Stephen Morris, Richard Murray, Newburry Astronomical Society, David Payne, Graham Pointer, Jonathan Powell, David Pritchard, Martin Puckett, Peter Quilter, Christopher Reitter, Ian Rigney, Robin Scagell, Alan Smeaton, George Spalding, Stirling Astronomical Society, Alex Thomson, Adrian Tighe, Robert Townsend, Martin Trotter, Sharon Turvey, West Midlands Astronomical Society, Christopher Willot, Simon Wragg.

2. Analyses

Data reduction was only carried out for information from reliable observers obtained under conditions where the limiting magnitude was +5.5 or better and where less than 20% cloud cover was present. These strictures necessitated the removal of all but a core of 975.24 hours and 5660 meteors, owing largely to the essentially inexperienced nature of most JAS Meteor Section observers. Analyses were performed to establish magnitude distributions, meteor rates and persistent train details.

Table 1 presents information on the conditions encountered and the observing time possible in each month, while Table 2 shows conditions, corrected mean magnitude for +6.5 skies ($\overline{m}_{6.5}$) and train properties for each year.

Table 1 – Hours of observation possible, percentage of nights observed on at least once in the five-year period and mean observing conditions by month for the 1984–1988 sporadic analysis.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Hours	91.24	42.50	73.28	98.52	24.84	2.58	21.65	211.75	107.05	127.25	88.57	86.40	975.24
% Nights	41.9	44.8	64.5	60.0	45,2	6.7	64.5	83.9	60.0	61.3	63.3	48.4	53.7
Lm	5.68	5.76	5.72	5.78	5.61	5.61	5.80	5.78	5.77	5.78	5.64	5.62	5.71
% Clouds	1.6	3.0	0.9	1.3	0.4	2.9	2.8	3.3	1.9	1.3	1.2	3.4	2.0

Table 2 – Annual details for conditions and sporadic meteors seen between 1984 and 1988

Year	1984	1985	1986	1987	1988	Tot
Mean Lm	5.79	5.69	5.79	5.71	5.61	5.71
Mean Cloud %	1.0	1.5	2.9	2.1	2.0	2.0
$\overline{m}_{6.5}$	3.13	3.27	3.11	3.31	3.03	3.21
Mean train %	10.5	10.8	11.3	6.0	8.4	9.1

3. Magnitude distributions

Sporadic magnitudes were studied first in order to establish figures for the population index r which could then be used in rate analyses. Monthly distributions, mean, corrected mean and r-valued were derived from the graph in [2].

The overall mean r of 3.15 in good agreement with the generally accepted value of 3.0, though clearly there are some variations from month to month on occasion, in particular February, June (although this is almost certainly due to the small meteor sample) and August.

Corrected mean magnitudes for each of the five years are presented in Table 2, with no real variation apparent in this figure between different years.

Table 3 – Sporadic monthly magnitude distributions for the period 1984–1988.

Month	-3^-	-2	-1	0	+1	+2	+3	+4	$+5^+$	Tot	$\overline{m}$	$\overline{m}_{6.5}$	r
Jan	2	2	11	24	66	109	131	94	27	466	2.50	3.32	3.40
Feb	4	1	4	18	22	37	49	28	8	171	2.21	2.95	2.26
Mar	2	3	7	16	26	63	94	54	9	274	2.41	3.25	3.23
Apr	6	6	11	26	37	81	128	87	25	407	2.47	3.19	3.12
May	0	1	2	6	22	10	27	14	9	91	2.42	3.31	3.37
Jun	0	0	0	1	2	2	1	1	0	7	1.86	2.75	2.53
Jul	3	9	5	39	54	99	153	119	58	539	2.68	3.38	3.50
Aug	10	13	19	65	127	261	378	297	133	1303	2.72	3.44	3.71
Sep	3	7	12	49	82	133	174	120	38	618	2.43	3.16	3.10
Oct	4	3	13	47	88	131	192	135	62	675	2.58	3.30	3.37
Nov	3	6	11	39	75	109	144	105	20	512	2.36	3.22	3.21
Dec	4	4	16	55	94	116	176	112	20	597	2.28	3.16	3.10
Tot	41	55	111	385	695	1151	1647	1166	409	5660	2.42	3.21	3.15

Examination of the magnitude distributions for various hours of the night (Table 4) also showed no significant trends away from the mean values when an adequate body of data was available (essentially between 21h UT and 02h UT).

Table 4 – Sporadic meteors numbers, mean magnitudes and train percentages for each hour of the night (UT) during the period 1984–1988.

Start	17^h	18^h	19^h	20^h	21^h	22^h	23^h	0^h	1^h	2^h	3^h	4^h	5^h	6^h	Tot
Met	8	41	68	137	499	1065	1283	1122	655	380	176	135	82	9	5660
$\overline{m}$	1.38	2.00	3.14	2.36	2.50	2.44	2.43	2.51	2.38	2.42	2.60	2.94	2.10	2.69	2.42
Trains	25.0	12.2	10.3	7.3	8.0	9.4	9.0	8.9	9.2	9.2	8.5	10.4	9.8	0.0	9.1

4. Meteor rates

Using the appropriate values derived from Tables 1 and 2, mean computed hourly rates (CHRs) were compiled for the sporadics seen during each month of the year using the formula:

$$\mathrm{CHR} = \frac{F \times C \times N}{T},$$

where F is the cloud cover correction, C the correction for the limiting magnitude, N the number of sporadic meteors seen, and T the effective observing time.

This is ostensibly as outlined for ZHR calculations in [2], but omitting the radiant correction factor, as sporadics by definition have no single radiant. Figures were similarly derived for sporadic $CHRs$ for each hour of the night too, although here standard correction values based on a mean cloud cover of 2% ($F = 1.02$), a mean Lm of +5.71 and an average r of 3.15 ($C = 2.48$) were utilized chiefly because conditions varied little from these mean figures across the night. Standard error parameters were appended to each figure as the analyses proceeded.

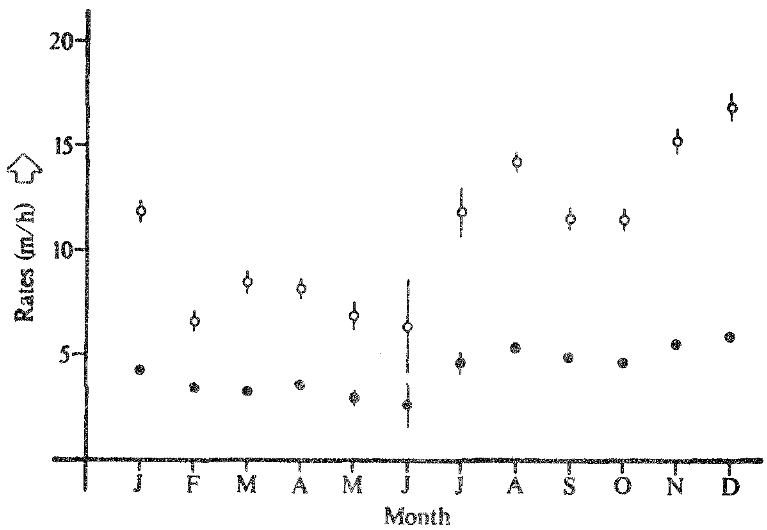

Figure 1 – JAS Meteor Section sporadic analysis, 1984–1988, annual sporadic variation. Filled circles show OHRs, open circles CHRs.

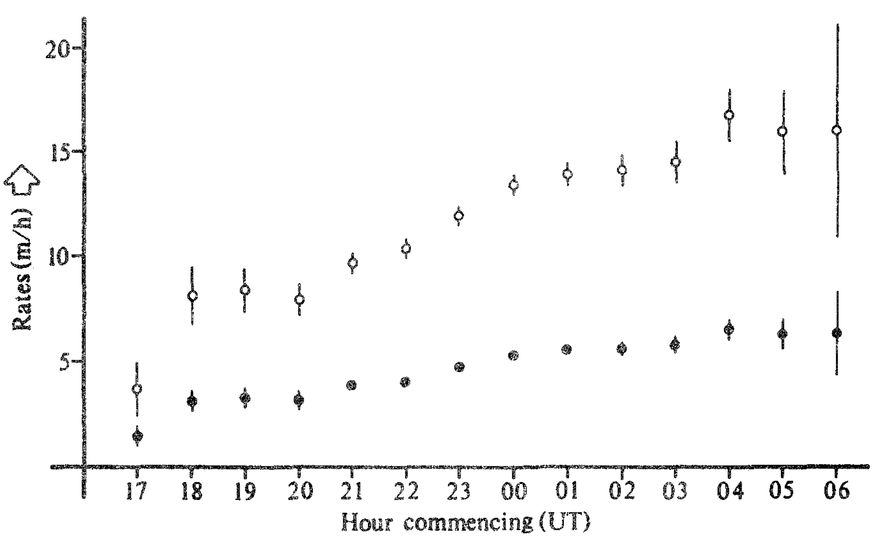

Figure 2 – JAS Meteor Section sporadic analysis, 1984–1988, diurnal sporadic variation. Filled circles show OHRs; open circles CHRs.

While the CHRs provide sporadic data which can then be compared directly, in limited terms, with shower ZHRs, they do not indicate, except in a very exaggerated way, what an observer from an average British site might expect to see under good routine conditions, and so a series of mean observed hourly rates (OHRs) using no correction factors was also produced from the same data. Both CHRs and OHRs were then plotted as graphs in Figures 1 and 2.

The highest annual CHR occurred in December at 17.0 ± 0.7 meteors per hour (the equivalent OHR was 6.0 ± 0.3), while the lowest—ignoring June, as this was based on too little data—was found for February at 6.6 ± 0.5 (OHR of 3.5 ± 0.3). Comparing the annual graph with those based on radar data in [1] and [2], as well as visual graphs in [3] and [4], the broad trends are roughly similar, tough in detailed shape, Figure 1 is closer to that in [2] than elsewhere. Even here, however, the dip seen in rates during September and October was not apparent.

The diurnal graph's steady increase for much of the night (for the UK, UT is about the same as local time throughout the year) from a CHR of 8.0 ± 0.7 at 20^h UT (OHR of 3.2 ± 0.3) to 14.2 ± 0.8 (OHR of 5.6 ± 0.3) by 2^h UT is much as expected, although the increase is far less marked than that found with radar results in [2].

5. Persistent trains

Finally, reports on the proportions of sporadic meteors showing persistent trains and their durations were examined. These results are given in Tables 2, 4, 5 and 6. Note that no sporadic meteor fainter than magnitude +4 exhibited a train.

The monthly proportions of trained meteors show a wide range of values, though again February, May, and June are based on a small sample overall. Comparing trains to magnitude classes revealed a lessening proportion of trains with fainter meteors, and a similarly decreasing trend for the train durations. Examining the train details for different hours of the night showed essentially a small-scatter distribution about the mean, where the data base was sufficiently viable.

Table 5 – Monthly mean percentages of trained sporadic meteors, 1984–1988.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
% Trains	7.9	5.3	4.7	10.8	15.4	28.6	7.8	7.1	9.4	9.9	14.1	10.6	9.1

Table 6 – Mean percentage of trained sporadic meteors per magnitude class, with mean train durations, 1984–1988.

Magnitude	-3^-	-2	-1	0	$+1$	$+2$	$+3^+$
% Trains	58.5	60.0	41.4	35.8	20.9	8.3	1.1
Duration	$4\overset{s}{.}4$	$1\overset{s}{.}6$	$1\overset{s}{.}5$	$1\overset{s}{.}2$	$1\overset{s}{.}0$	$0\overset{s}{.}9$	$0\overset{s}{.}8$

6. Discussion

Although on average only about half the nights in each month were covered at least once during the five-year spell, the results produced compare favorably with other published elsewhere, and it seems reasonable to assume at least a general level of accuracy within them.

The diurnal examinations of meteor magnitudes and trains revealed distributions not greatly at variance with the mean values, suggesting that there are no real changes to be found in these features. However, looking at fireballs alone (meteors of magnitude -3 or brighter), a possible trend is apparent as shown in Table 7.

Table 7 – Numbers (N) and percentages (%) of sporadic fireballs for each hour of the night, from the 1984–1988 data.

Start	17^h	18^h	19^h	20^h	21^h	22^h	23^h	0^h	1^h	2^h	3^h	4^h	5^h	6^h
N	0	1	3	4	4	5	6	10	3	3	1	1	0	0
%	0	2.4	4.4	2.9	0.8	0.5	0.5	0.9	0.5	0.8	0.6	0.7	0	0

The possible fireball "peak" between 18^h and 20^h UT may simply be due to chance, since the total numbers of sampled sporadics in the hours preceding 21^h UT are low, though it is interesting that this effect does not recur after 3^h UT when similar totals of sporadic meteors were achieved. Some support for this can be found in the higher proportion of trained meteors near this period and also in [5], suggesting it may not be totally illusory.

Sporadic activity appeared to increase by a factor of about two from 18^h to 4^h UT, though the errors before 20^h UT and after 2^h UT make the highest and lowest figures rather tentative at best, with the time of maximum rates being particularly poorly defined. The CHR range does fit well with recently-made bulk sporadic analyses, however—see for instance the sporadic details in [6].

In annual terms, the months of February, May and June received least attention: the data for June in particular are so slight as to make them worthless. Ignoring these three months when examining the sporadic magnitudes leaves only August as somewhat anomalous, with a $\overline{m}_{6.5}$ of 3.44, compared to the overall $\overline{m}_{6.5}$ of 3.21. From the annual activity graph, it is clear that August also seems to enjoy a small peak in its CHR, and it may be that both are the result of the misidentification of some faint minor shower meteors. If this is so, then the September-October "dip" may simply be a continuation of the July-August rates, with the actual increase occurring in November. Alternatively, the August "anomalies" may just be the result of a much greater concentration of data than for any other month.

Table 8 – Monthly totals (N) and percentages (%) of fireballs, from the 1984–1988 data.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
N	2	4	2	6	0	0	3	10	3	4	3	4
%	0.4	2.3	0.7	1.5	0	0	0.6	0.8	0.5	0.6	0.6	0.7

Although there are no clear variations in sporadic brightnesses overall during the year, looking again solely at fireballs (Table 8) shows enhanced activity during February and April. The four February events were all of magnitude -3 and are therefore probably not indicative of anything significant, whereas for April, meteors of magnitude classes -3 to -6 occurred in several separate years, suggesting a possible confirmation of the general view that April is relatively rich in these bright meteors. This is similar to what [5] indicates too. Once more, however, the small sample of fireballs makes definite statements on this matter difficult.

The difference between the highest and lowest sporadic annual CHR values is about a factor of 2.5 times the lower rate, with activity generally poorest in late winter and spring and best in late autumn to early winter, though some previous results have suggested comparable sporadic hourly rates from September through to December, which is not confirmed here. As mentioned earlier, the June data can effectively be discarded and August's "mini-peak" and its consequences for September and October, have also been discussed.

The proportion of trained sporadics over the year shows quite a wide variation, which (setting aside February, May and June) to some extent resembles the sporadic CHR trends, though often not exactly. November seems to bring the most trained sporadics, but the entire autumn to early winter spell is reasonable for such events according to these results. The sudden drop in train proportions in 1987 and 1988 compared to earlier years seems to fit into no real pattern on this timescale, but possibly the state of the upper atmosphere related to the solar cycle may be involved. Late 1986 brought the most recent sunspot minimum, when a high percentage of trained sporadics was seen, but solar activity remained low throughout 1987 too, which poses further difficulties. When comparing the percentages and duration of sporadic trains with their magnitudes, the decreasing trend found in both items was largely as expected from earlier JAS Meteor Section results—for example, see [7].

The sporadics appear to maintain a relatively fixed character on both long and short timescales in terms of their magnitude distributions and probably trains too. In the case of these latter items, assuming some external agency to be responsible for the variations seen, and that meteor trains in general are produced by the same physical and/or chemical processes at about the same heights above he Earth (which seems to be true for many shower meteors at least), it seems reasonable that both sporadic and shower meteor trains should be affected in roughly equal terms. Thus it becomes viable to directly compare sporadic magnitude distributions and train characteristics with those for showers.

In the instance of meteor rates, however, such a direct comparison is rather less useful, since sporadic activity varies both with the time of year, and during the course of the night. Here, it would probably be better to use either mean sporadic CHRs or re-compute the CHRs to allow for diurnal variation at least, but this latter method would require some definitive studies to prepare diurnal results of sufficient accuracy. A correction to allow for the annual changes would further refine the CHRs, though this is perhaps less important.

7. Future work

From the above, in parts rather tentative, results, there are several areas which are in need of immediate attention. More pre-20^h UT and post-2^h UT data are needed, together with an increase in watches during February, May and June. Unfortunately, from the UK, most of these are rather difficult aims. February's weather is often notoriously poor, while June, much of May and July suffer from heavily-twilit conditions. A greater awareness of minor shower activities in August could show whether the slightly anomalous results from that month are genuine or not, while the whole question of meteor trains per month and on longer timescales will require regular attention.

On a broader scale, we may perhaps look forward to regular *IMO* sporadic reports for various latitudes in both northern and southern hemisphere, wich will give a far more accurate picture over a shorter period than is clearly possible with a localized analysis like this one. It is particularly important, then, that data collection by all observation methods should not concentrate solely on times near major shower's maxima, since the routine checking of sporadic activity is important for its own sake, as well as for keeping shower calibrations up to the date, while the beginnings of new streams or the existence of many minor showers may be waiting to be found.

References

[1] A.C.B. Lovell, "Meteor Astronomy", Oxford University Press, 1954.

[2] P. Roggemans (ed.), "Handbook for Visual Meteor Observations", 1989.

[3] G. Baldacchino (ed.), "Meteors—An Observer's Handbook", 1980.

[4] A. McBeath, "Sporadic Meteors", *Popular Astronomy* 32:3, 1985, pp. 93–95.

[5] R. Koschack, J. Rendtel, "Fireballs", in *[2]*, pp. 91–93.

[6] P. Roggemans, "The Perseid Meteor Stream in 1988: a Double Maximum!", *WGN* 17:4, August 1989.pp. 127–137

[7] A. McBeath, "JAS Meteor Section Visual Results: 1988 Perseids", *WGN* 16:6, December 1988, pp. 195–197.

1988 Observational Results from Norway

Trond Erik Hillestad

An overview is given of observations carried out in Norway during 1988.

Numerous observations can be communicated from Norway in 1988. The Perseids, κ-Cygnids, Taurids and Geminids all had fine weather and a nice coverage. The minor showers of spring and autumn where not heavily observed, contrary to 1987. The number of observers rose to 6, which is considerably better than in 1987. Still, only 30% of the members were active visually. The observers got in a total of 135 man hours from 45 nights, a normal result. 4700 meteors were seen, making the year a good number two on the high score list of the Section.

This fine visual result was possible thanks to the efforts of:

> Kai Gaarder (KG), Roar Hanoa, Lars Trygve Heen (LTH), Trond Erik Hillestad (TEH), Olaf Skjæraasen and Magne Svanemsli.

The rate data and magnitude distributions of 1988 are collected into an annual report. It can be obtained by writing to my address (see back cover).

The second Norwegian Meteor Camp was arranged in 1988. The camps are informal gatherings where amateurs meet to talk with each other, and observe. No lectures are given, apart from a minor introduction to observing methods. They are arranged during one week under the Perseids. Only first-class observing sites are used. Such conditions are obtained from the southernmost parts of the country. North of latitude 60°, dusk will ruin the clearest of skies even at midnight. The Meteor Camps of 1986 and 1988 were both very successful. From now on, they will be arranged every year if the Moon allows for it.

The δ-Leonids and Virginids were monitored by KG and LTH during 6 nights of February and March. Activity was always below 3 meteors per hour. Too few meteors were seen to make a good activity curve. Few meteors was also the situation after the 1988 Lyrids.

The Perseids were monitored with great effort from the Meteor Camp on latitude 58° N. 5 of 7 nights had perfect conditions, while 2 had only partially clear skies. This is considerably above the average of what can be expected from the standard August weather of Norway. The maximum nights were cloudy from most other observing sites, and this explains why only the 6 people of the Meteor Camp saw the Perseids. It is a pity that many amateurs do not bother to observe showers off-maximum. The very perceptive KG got 120 Perseids at most, but other experienced observers had uncorrected rates of 90 around August 12.0 UT (limiting magnitude 6.1–6.4). It seems reasonable to conclude that the shower was "good" in 1988, but slightly less active than 1986 when our high-perceptive observers got rates exceeding 100. Perhaps we had more luck "hitting" the main peak in 1986.

The κ-Cygnids start just before Perseid maximum. This shower is very popular among our hardest-working observers, as the radiant is always very high in the Norwegian sky. KG, LTH and TEH had uncorrected rates of 1–6 during the Perseid maximum. One can however never exclude the possibility of shower contamination, as values of 4–6 seem very high for the kappas this early. About 4 per hour were seen on August 17.9 UT.

KG and LTH once again produced results from the Taurid showers of October and November. Observations were made on 9 different evenings, so an activity curve is not easy to make. At most, KG saw 5 Southern Taurids per hour on November 3, and 6 Northern Taurids per hour on November 13. A total of 569 Geminids were seen from December 6 to 15. The results of KG and LTH make a nice activity curve peaking late on the 13th, when ZHRs rise to about 125, or some 10 times the sporadic activity.

Observing Summary: Alberta, May–August 1989

Peter Brown

An overview is given of observations carried out in Alberta, Canada between May and August 1989.

Observing these past few summer months have been characterized by twilight, aurorae, mosquitoes, and good luck. All of May, June and the most of July were wiped out as usual by local heavy twilight. Even the first session at the very end of July was filled with twilight.

As the mont of August opened, twilight faded and the observing weather improved. Every single session I recorded on in August had a substantial aurora display occur sometime during the night, however, each display always stayed essentially to the North, leaving the Southern half of the sky aurora-free and dark enough for serious observations. This lucky fact, coupled with 7 clear nights in a row from August 5 on from Ft. McMurray helped make the 1989 Perseids a shower worth remembering.

The five clear nights in which observing was attempted during the pre-maximum period of the shower were somewhat disappointing with rates lower than might be expected on many of the nights. In particular, the night of August 8–9 saw Perseid hourly rates stay well below 15 even towards early morning, though a great deal of clouds and intense auroral glow are likely the culprits.

In terms of magnitude no clear pattern emerges for these nights. The only general observation is that the pre-max nights were substantially fainter than both the Aug 11–12 and Aug 12–13 nights when observations took place in the main Perseid peak plateau.

August 9–10 and 10–11 were spoiled in Ft. McMurray by bright aurorae and mid-level clouds. With more poor weather and bright aurora in the forecast, a 600 km trip to central Alberta seemed in order and after a full day of driving on August 11, I reached Red Deer Lake with Mark Zalcik from Edmonton and two other observers also in attendance. We found a nice quiet location by the beach and began observing at midnight local time after the Moon had set.

Maximum on the night of August 11–12 was quite strong and very comparable to the 1988 return. Although I was a bit more tired this year during the peak than I had been in 1988 all other conditions were nearly identical. As in past years the shower took two hours to really get going after which time the radiant was high enough to really let rates take off. Going from 40 to 56 to 74 Perseids an hour, I was struck by the feeling that the shower was increasing at a frantic pace and welcomed twilight as a chance to let the plastic buttons on my tape recorder recover and survive for the next evening. This night turned out to be filled with many bright meteors. Oddly enough, the night of maximum was some 0.70 magnitudes brighter than the average for the entire stream, an effect I have not experienced in past years. This was the first night where I would say a disproportionate number of bright meteors appeared. Outstanding in this regard were a −7 and −5 fireball both of which left trains lasting more than 10 seconds.

The night of August 12–13 looked less than promising at first, but by 0130 UT the situation turned around completely. Rates on this night were anticlimatic after the previous night peak, and only the first hour gives a real indication of what the true situation was like as I was almost asleep halfway through the second hour. August 12–13 appears to have been a relatively normal declining peak night, with hourly rates barely able to top 30.

Once again the Perseids have produced another outstanding year. Predictions suggesting the shower is on the decline seem to have been premature. Other reports I have received from observers in Western Canada suggest the shower was as strong as 1988, but nowhere near the 1980 or 1981 displays.

Weight restrictions *prohibit it us from adding even more pages to this record issue and volume of WGN! Observational reports by Richard Taibi and José Trigo will be published in the Februari issue! (Ed.)*

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IMO International Meteor Weekend 1990

Be sure to participate in the next meteor weekend in 1990, plan your holidays and make your reservation right now:

Dates:

Begins: Thursday evenening September 6, 1990
Ends: Sunday noon September 9, 1990.

Place:

Bruder-Klaus-Heim, in D-8901 Vilau, FRG
(near the city of Augsburg)

Program:

Introduction of observing groups, lectures on meteors and related fields, poster presentations, excursion to the Augsburg planetarium (optional), 2nd General Assembly of *IMO*. The official language is English.

Accomodation:

Accomodation will be in 4-bed rooms. Make your reservations early, since the number of rooms is limited! The estimated price for accomodation, full board and participation at the conference is around 140,- DEM,

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